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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Imaginary Numbers

Heat Transfer Processes

Man's Use of Rocks and Minerals

Mathematics in the Junior College

Our Knowledge of the Vitamins

The Study of Chemistry

In a Sound Studio

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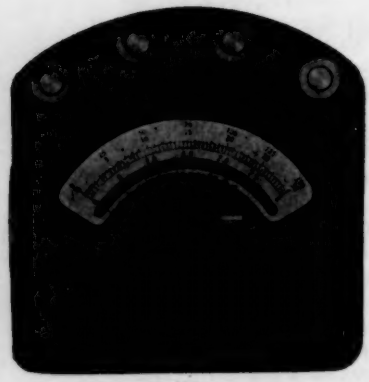

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVII MARCH, 1937 WHOLE NO. 320

IS THERE ANY USE FOR IMAGINARY NUMBERS?

BY P. H. NYGAARD

North Central High School, Spokane, Washington

Students who are introduced to imaginary numbers in high school or college mathematics classes learn a great deal about the handling of such numbers. They have no misgivings about finding solutions for quadratic equations even if square roots of negative numbers are encountered. They can add, subtract, multiply, and divide quantities involving imaginaries. Most of them also learn how to plot numbers by means of a coordinate system having two mutually perpendicular axes, one for the real and the other for the imaginary values. After learning all this, the students naturally expect that they will be shown some of the applications of imaginary numbers. Since the text book does not satisfy their curiosity, they ask the teacher in a rather exasperated tone: "What are imaginaries good for anyway?"

To this question most teachers answer, in effect, that imaginaries are important in higher mathematics, but an explanation of their use would be too difficult for the students to understand. Such an answer is obviously unsatisfactory. The writer of this article believes that it is possible to explain to such students some of the uses of imaginaries in a way that they can comprehend and at the same time give them a stimulating glimpse of interesting methods of advanced mathematics. An attempt will be made in what follows to present such an answer, which has been used by the writer in his higher algebra classes in high school. The discussion will be given in such form that both

teachers and students of mathematics may, it is hoped, benefit from reading it.

It may be well at the outset to summarize what is usually taught about imaginaries in an introductory course. An imaginary number is defined to be an indicated square root of a negative number. All other numbers are called real. A complex number consists of two terms, one real and the other imaginary. In expressing imaginary numbers the letter i is used, its definition being $i=\sqrt{-1}$. Hence it follows that $i^2=-1$. Thus, $-5+\sqrt{-3}$ is a complex number consisting of the real term -5, and the imaginary term $+\sqrt{-3}$; in the i form it would be written $-5+i\sqrt{3}$. A quadratic equation has two roots, both of which may be real, both may be imaginary, or both may be complex. The roots of $x^2+2x+6=0$, found by completing the square, are $-1+i\sqrt{5}$ and $-1-i\sqrt{5}$, both complex. All real numbers can be located along a horizontal straight line having a certain point marked zero, having its scale to the right marked with the positive numbers $+1$, $+2$, $+3$, etc., and its scale to the left marked with the negative numbers -1, -2, -3, etc. To locate imaginary numbers a second line is introduced, drawn perpendicular to the first and having the same zero point. Above the zero point its scale is marked with the imaginary numbers $+1i$, $+2i$, $+3i$, etc., and below it with the imaginary numbers $-1i$, $-2i$, $-3i$, etc. Any real number can be located as a point on the horizontal, or real, axis, and any imaginary as a point on the vertical, or imaginary, axis. A complex number will also be a point, but not on either axis. Thus, the complex number $-2\frac{1}{2}+3i$ will be a point $2\frac{1}{2}$ units to the left of, and 3 units above, the origin.

Two applications of imaginary numbers will be discussed, neither of which assumes any more knowledge of the subject than is outlined above. Readers familiar with higher mathematics will recognize the first as an approach to the topic known as the cyclic roots of unity and the second as an introduction to vector analysis.

1. CONSTRUCTION OF REGULAR POLYGONS

It is easy by means of plane geometry methods to inscribe various regular polygons in a circle. It does not seem that imaginary numbers should have anything to do with such construction problems, but it is nevertheless a fact that the two subjects are closely related. Gauss, when only 18 years old,

inaugurated his great career of mathematical achievement by showing that a 17 sided regular polygon can be inscribed in a circle by means of the postulates of plane geometry. His method, however, is full of imaginaries from beginning to end. The plan followed by Gauss is essentially as follows: To inscribe a regular polygon of n sides in a circle whose radius is one unit, find the roots of the equation $x^n-1=0$. This equation will have n roots, each of which will locate one vertex of the required regular polygon.

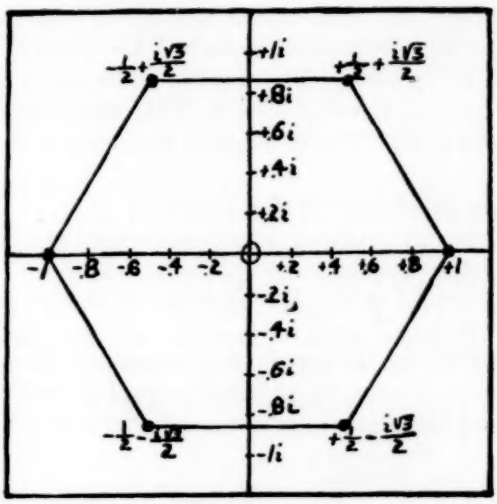

FIG. 1.

The construction of a regular 6 sided polygon by means of imaginaries will be worked out in detail. Here $n=6$, so the equation to be solved is $x^6-1=0$. This is equivalent to $(x^3-1)(x^3+1)=0$. Further factoring gives $(x-1)(x^2+x+1)(x+1)(x^2-x+1)=0$. Placing $x-1=0$ gives $x=+1$. Placing $x+1=0$ gives $x=-1$. Solving $x^2+x+1=0$ by completing the square gives $x=-\frac{1}{2}+\frac{i\sqrt{3}}{2}$ and $x=-\frac{1}{2}-\frac{i\sqrt{3}}{2}$. Similarly, $x^2-x+1=0$ gives $x=+\frac{1}{2}+\frac{i\sqrt{3}}{2}$ and $x=+\frac{1}{2}-\frac{i\sqrt{3}}{2}$. Now locate the points corresponding to these six roots on the real and imaginary coordinate system, as shown in Figure 1. The root $+1$ is the point

one unit to the right of the origin, and the root -1 is one unit to the left of the origin. The complex root $-\frac{1}{2}+\frac{i\sqrt{3}}{2}$ is the point $\frac{1}{2}$ unit to the left of, and $\frac{\sqrt{3}}{2}$ units above, the origin. The other three complex roots are similarly located. The roots give 6 points as shown. These 6 points form the vertices of the required regular hexagon.

It is obviously easy in a similar manner to inscribe regular 3 sided and 4 sided polygons, because $x^3-1=0$ and $x^4-1=0$ are easily solved by factoring. The regular pentagon is not so easy, as will be shown. Here $x^5-1=0$. This factors readily into $(x-1)(x^4+x^3+x^2+x+1)=0$. Further factoring is very difficult by elementary methods, but gives $(x-1)\left(x^2+\frac{(1+\sqrt{5})x}{2}+1\right)\left(x^2+\frac{(1-\sqrt{5})x}{2}+1\right)=0$, which may be readily verified by multiplication. From the first factor is obtained the root $x=+1$. From the second factor, by placing it equal to zero and solving by completing the square, is obtained the two complex roots $x=-\frac{1+\sqrt{5}}{4}\pm\frac{i\sqrt{10-2\sqrt{5}}}{4}$. Similarly, from the third factor is obtained the two complex roots $x=+\frac{\sqrt{5}-1}{4}\pm\frac{i\sqrt{10+2\sqrt{5}}}{4}$.

By locating these five roots on the real and imaginary coordinate system as shown previously for the hexagon, the vertices of the regular pentagon are obtained. It may be remarked in passing that it is possible to construct by ruler and compass any required distance whose value is given by the processes of adding, subtracting, multiplying, dividing, or finding the square root of whole numbers, no matter in what sequence the processes occur nor how often they are repeated. This means that the roots of any linear or quadratic equation with real coefficients can be determined by use of the authorized plane geometry constructions, whereas roots of general equations of the third degree, or higher, cannot be found in this way.

Regular polygons having 7, 9, 11, 13, 14, 18, and 19 sides cannot be constructed by means of the postulates of plane geometry. This is because their respective equations, according to the plan used by Gauss, cannot be factored into linear or quadratic factors. All the other regular polygons having 20 or less sides can be constructed by the ordinary ruler and compass methods, because in each case the corresponding equation can be factored into linear and quadratic factors, and hence the complex roots can all be located. To construct the 17 sided regular polygon Gauss had to solve the equation $x^{17}-1=0$. One factor is obviously $x-1$, which gives the root $x=1$. There are 8 other quadratic factors found by Gauss, all of which are so full of radicals that it would be out of the question to state them here. These 8 factors give 16 complex roots. The points determined by the 17 roots will be the vertices of the regular 17 sided polygon.

2. RESOLUTION OF FORCES

In physics, and sometimes in plane geometry, it is shown that the resultant of two forces can be found by the "parallelogram" law. The method consists in laying off from a common point two line segments whose respective directions are the same as the directions of the two given forces and whose

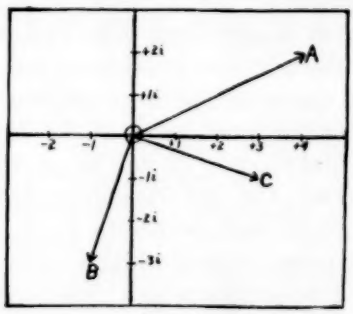

FIG. 2.

respective lengths are in proportion to the magnitudes of the two forces, then constructing a parallelogram having these two line segments for two of its sides, and finally drawing from the common point the diagonal of the parallelogram. This diagonal represents the resultant force both in direction and magnitude.

It may surprise you to learn that problems of this kind can be readily solved by the addition of complex numbers, and that the "parallelogram" law is a consequence of the way in which

such numbers are added. A simple illustration will make this clear. Let the lines OA and OB in Figure 2 represent two forces both in direction and quantity. Such lines are technically known as vectors. A is the complex number $4+2i$ and B is $-1-3i$. Their sum is obviously $3-i$. Locate this complex number, designated C in the figure. Draw the vector OC. This vector is the resultant of the forces. By drawing BC and AC it is easily seen that OC is also the diagonal of the parallelogram on OA and OB.

The general procedure for finding the resultant of two or more forces by means of the addition of complex numbers is as follows: On the real and imaginary coordinate system represent the various given forces as vectors having the origin as their common point. For each vector determine the location of its end point in the form of a complex number. Find the sum of these complex numbers. On the coordinate system place a point that shall correspond to the complex number thus obtained. From the origin to this point draw a vector, which is the required resultant. The resultant of two velocities can be found in exactly the same way. It should be noted that the complex numbers are simply used as an aid in the solution; neither the original statement of the problem nor the final result contains any trace of imaginaries.

A typical problem dealing with velocities will now be completely solved by the addition of complex numbers. Suppose it is required to find the resultant if an airplane, whose speed in still air is 200 miles per hour, heads N 30° E, but is blown off its course by a wind moving N 30° W at 50 miles per hour. In Figure 3 the vectors OA and OB represent the two velocities. By drawing AF and BG both perpendicular to the real axis, two right triangles are formed, from which it is found that A is the complex number $100+100i\sqrt{3}$ and B is $-25+25i\sqrt{3}$. Their sum is $75+125i\sqrt{3}$. This locates C in the diagram, and OC is the required resultant. The velocity may be obtained by measuring the length of OC on the drawing and the direction by measuring the angle which OC makes with one of the axes. If more accuracy is desired, the length of OC and its angle can both be computed without resort to measurement. To do this draw CD perpendicular to the vertical axis. Then, since C is the complex number $75+125i\sqrt{3}$, the right triangle OCD gives $OC=\sqrt{75^2+(125\sqrt{3})^2}=\sqrt{52500}=229,$. approximately. The

tangent of angle $DOC = \frac{75}{125\sqrt{3}} = .3464$. A trigonometric table then gives angle $DOC = 19°$, approximately. Therefore the airplane will travel N 19° E at 229 miles per hour.

The method just outlined is especially effective if there are more than two forces or velocities to be resolved. The parallelogram method becomes tedious, because it is necessary to use more than one parallelogram. On the other hand the method

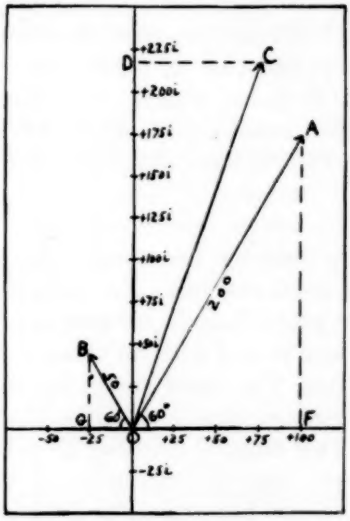

FIG. 3.

using the addition of complex numbers is nearly as easy as before, the only difference being that more than two complex numbers must be added.

The complex number method is also easily adapted to solving the converse problem—that is, if one force is given and it is required to find a second force so that the two together shall produce a given resultant. The only change in the method is that it is necessary to find the difference between, instead of the sum of, the obtained complex numbers.

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RECENT ADVANCES IN OUR KNOWLEDGE OF THE VITAMINS

By Harold L. Mason

Division of Biochemistry, The Mayo Foundation, Rochester, Minnesota

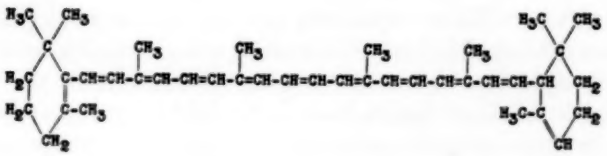
For some thirty years scientific workers have been studying those substances which occur in foodstuffs in very minute quantities but which are essential for proper nutrition. The many studies that have been made during those years are now coming to fruition. The complete structural details of five of the vitamins are known, and four of them have been prepared in the laboratory by chemical means. The chemical knowledge obtained has revealed relationships which have stimulated new lines of research and which have enabled us to understand better the functions of the vitamins.

Since the vitamins are present in such very small quantities, the task of isolating them has been beset with many difficulties. Vitamin B offers a good example. The isolation of this vitamin was delayed many years, largely on account of its instability. It was not uncommon to end with no vitamin at all after a long and laborious process. The most successful isolation from rice polishings yielded 5 gm. of pure crystalline vitamin B from 1 ton of the polishings. This amount is about 25 per cent of the vitamin that is present. The micromethods of manipulation and analysis which have also been developed during this time have been of great service. A few milligrams of material now suffice where several hundred milligrams would be necessary for the usual methods.

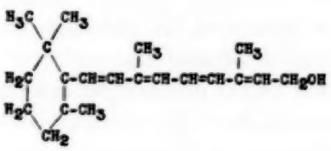
A number of years ago Steenbock, at the University of Wisconsin, suggested that carotene possessed vitamin A activity. Carotene is the yellow coloring matter of carrots. It also occurs in yellow corn, in butter and all green leaves. All of these foods are rich in vitamin A. A little later two European workers proved definitely that Steenbock's idea was correct, but at the same time it was recognized that the vitamin A which is found in cod liver oil was not carotene. Shortly afterward the vitamin A of cod liver oil was isolated in a sufficiently pure state so that its chemical nature could be determined. It was found to be a highly unsaturated alcohol which is derived from carotene by cleavage in the middle of the molecule. This relationship is shown in figure 1.

The striking thing about the carotene molecule is the large number of double bonds, eleven of them. The accumulation of so many double bonds causes this molecule to be very reactive chemically. It is so reactive that it absorbs oxygen from the air quite rapidly. If now by some selective process carotene could be split between the ninth and tenth carbon atoms of the chain, with placement of an alcohol group on the ninth carbon atom, vitamin A would be the result. That is exactly what happens, presumably in the liver. Thus the vitamin A activity of carotene is explained.

The molecule of α-carotene is not quite symmetrical. The



α-carotene



Vitamin A

FIG. 1

right-hand ring of carbon atoms is slightly different from the left-hand one, the left-hand ring being the same as that which is present in vitamin A. Consequently, α-carotene can yield only one molecule of the vitamin. There is another carotene known as "β-carotene" in which the two rings are identical. One molecule of β-carotene can yield two molecules of vitamin A and it has been adopted as the international standard of vitamin A.

A long-known characteristic of vitamin A is the ease with which it is destroyed by mild oxidation. As in the case of carotene, this behavior is accounted for by the many double bonds. As it occurs in nature the vitamin is accompanied by anti-

oxidants which preserve its activity for some time but not indefinitely. Storage at a low temperature and with the exclusion of light helps to prevent destruction of vitamin A by oxidation.

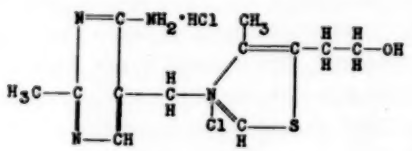
It is probable that in the normal individual carotene is adequate for vitamin A, but if there is a pathologic condition or a deficiency of the vitamin, the preformed vitamin A of cod liver oil is to be preferred since it is much more easily absorbed from the gastro-intestinal tract than is carotene. This is particularly true when there is an abnormal condition in the gastro-intestinal tract.

A good deal of publicity has been given to the idea that vitamin A in sufficient quantity confers protection against the common cold. A deficiency of vitamin A does cause a breakdown in the body's first line of defense against infection, the epithelial tissues. If these tissues lose their vitality, then infection by a cold or other disease occurs more easily; there is no evidence, however, that an increasing consumption of vitamin A can build these barriers against infection higher and higher. An intake of the vitamin which is adequate to maintain the epithelial tissues in a state of health is essential, but it is not likely that a large surplus is of any particular value. It should be noted, however, that the optimal intake of vitamin A is not known. A recent study of 200 students indicated that an intake (5000 units) almost double the amount which is usually considered adequate (3000 units) reduced the average duration of colds in this group, but the number of colds was not reduced significantly. Vitamin A is definitely not to be considered as a cure for, or as effective in the treatment of, colds.

Some individuals suffer from a lack of vitamin A, although they do not show the gross symptoms that are associated with a total deficiency. The condition of nutritional night-blindness is caused by an insufficiency of this vitamin. When the environment of the eye changes suddenly from light to darkness there is a temporary condition of blindness until the eye becomes adapted to the new environment. This adaptation of the eye consists of the formation of visual purple in the retina. The visual purple sensitizes the retina so that it can utilize light of small intensity. Vitamin A is essential for the formation of visual purple. A deficiency of the vitamin results in a deficiency of visual purple and a consequent inability to see at night. This ability is quickly restored by administration of vitamin A.

There is a color reaction of vitamin A which is being widely used to determine the amount of the vitamin in various foodstuffs. When antimony tri-chloride is added to a solution of the vitamin in chloroform, a blue color is produced, the intensity of the color being proportional to the amount of vitamin A present. The method is fairly accurate when applied to the nonsaponifiable fraction of cod liver oil, for example. A better, but not so readily available, method is measurement of the intensity of absorption at a particular wavelength in the ultraviolet.

Although vitamin B was the first vitamin to be discovered, it is the most recent one to succumb to chemical attack. The success of this work is due largely to the brilliant work of an American chemist, R. R. Williams. Dr. Williams became interested in vitamin B while employed as a government chemist in the Philippines. Although now engaged in industrial work entirely unrelated to vitamins, he continued to work on vitamin B in his spare time, and, with some help from Columbia University, finally isolated the vitamin and determined its structure. In August, 1936, he announced the synthesis of this vitamin (fig. 2).



Vitamin B hydrochloride

A dose of 0.005 mg. daily cures polyneuritic rats

FIG. 2

Very little is known as to the physiology of vitamin B. There is some indication that it plays a part in the utilization of carbohydrate. It is possible that some nervous disorders are directly attributable to a partial lack of the vitamin. A large deficiency, of course, results in polyneuritis or beriberi.

Vitamin C has rather a unique history. It was first isolated in 1928, but for four years it remained unrecognized as the vitamin. As soon as its identity was established there was feverish activity in several laboratories to establish its structure and to synthesize it. A group of English workers first succeeded in

doing this. The vitamin has now been synthesized by several methods. The method by which it is being produced commercially is illustrated by the formulas in figure 3.

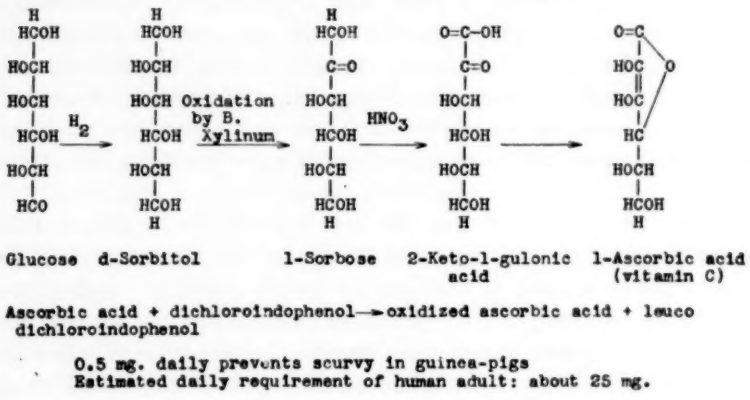

Glucose
d-Sorbitol
Oxidation by B. Xylinum
l-Sorbose
2-Keto-l-gulonic acid
l-Ascorbic acid (vitamin C)
Ascorbic acid + dichloroindophenol → oxidized ascorbic acid + leuco dichloroindophenol
0.5 mg. daily prevents scurvy in guinea-pigs
Estimated daily requirement of human adult: about 25 mg.

FIG. 3

Since vitamin C has the properties of an acid it has been named "ascorbic acid," referring to its ability to prevent and cure scurvy.

The rôle which ascorbic acid plays in the physiologic functions of the body is very obscure. It is interesting that some species, the dog and rat, for example, are independent of an outside source. They are able to make their own ascorbic acid. It has been stated that infants also have the ability to synthesize ascorbic acid, but that after a few months they lose this ability and become dependent on their food supply.

A striking chemical property of ascorbic acid is its very potent reducing property. An example of this property is the almost instantaneous reduction of gold chloride to metallic gold, which remains in suspension as a sol when ascorbic acid is added to a solution of gold chloride.

The reducing property of vitamin C is utilized for its estimation in foods. It has been found that a dye, dichloroindophenol, will oxidize vitamin C in acid solution, but that it will not oxidize other substances that will reduce some of the stronger oxidizing agents such as iodine. The titration with dichloroindophenol is then quite specific for vitamin C.

The formation of antirachitic substances by the irradiation of ergosterol and of various foods is commonplace nowadays. Rather recently it has become evident that viosterol produced

by the irradiation of ergosterol is not the same as the vitamin D of cod liver oil. In fact there are several different forms of vitamin D. For rats viosterol and the cod liver oil vitamin are of practically equal potency, but chicks require about 100 times as much viosterol as cod liver oil vitamin D. It seems probable that the two forms of vitamin D are not of equal potency for human beings, although the evidence on this point is conflicting. It appears that the cod liver oil vitamin is about three times as effective as viosterol. The ordinary therapeutic dose is 1,000 international units (or U. S. P. units) of vitamin D in the form of cod liver oil or about 3,000 units in the form of irradiated ergosterol.

Very recent work has shown that cholesterol may contain a small amount of impurity which can be activated by ultraviolet light but which is not ergosterol. Originally it was thought that cholesterol itself was converted to vitamin D by ultraviolet light. Then it was shown that an impurity was responsible for this property and the evidence seemed conclusive that this impurity was ergosterol. It now appears that the provitamin impurity of cholesterol is not ergosterol but some transformation product of cholesterol. It is probable that the vitamin D produced by the action of sunlight on the skin is derived ultimately from the animal sterol, cholesterol, and not from ergosterol, which is a plant sterol. There is a sharp cleavage in the physiologic properties of sterols from the two sources. Animals are not able to absorb plant sterols, although the vitamin D derived from ergosterol is readily absorbed.

Whatever may be the relation of ergosterol and its irradiation products to cod liver oil, the chemistry of these compounds is very important from a practical point of view since viosterol has found such a wide use in the maintenance of an adequate supply of vitamin D.

Figure 4 shows the structural relations between ergosterol and viosterol, or "calciferol" as it is more properly called. There are two physiologically inactive compounds intermediate between ergosterol and viosterol. On further irradiation viosterol changes progressively into three other compounds, one of which is decidedly toxic.

The question of the toxicity of vitamin D deserves some comment. Vitamin D is toxic in large doses, but there is a wide range between the ordinary therapeutic dose and the dose which produces adverse symptoms. The indications are that, in man,

toxic symptoms begin to appear when 600,000 units of vitamin D as irradiated ergosterol, or about 200 times the therapeutic dose, is administered daily over several weeks. As much as 2,760,000 units have been given daily without serious poisoning. This amount is equivalent to some 30 liters of cod liver oil, and is 920 times the ordinary dose. Earlier reports to the effect that irradiated ergosterol was toxic resulted from the use of preparations which had been over-irradiated and contained large amounts of toxisterol, which is definitely toxic in the range of the ordinary therapeutic dose. In view of our present knowledge there is no danger in the administration of adequate amounts of the viosterol preparations supplied by reputable firms.

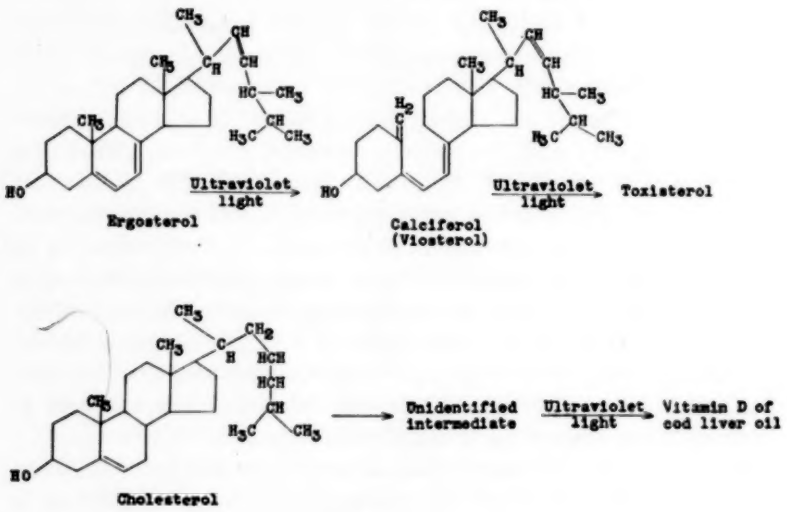
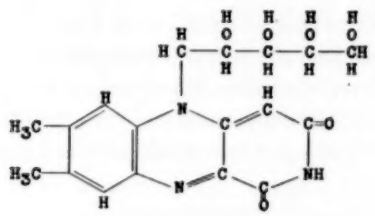


FIG. 4

As a result of the study of vitamin B it was found that in the extracts which contained this vitamin there was another essential food factor which was characterized by its greater stability to heat. It soon appeared that this vitamin, B_2 or G, was not a single substance but a complex, and some evidence has been brought forward for the presence in this complex of vitamins B_3, B_4, B_5 and B_6. Some of these are not well defined. There is still considerable confusion as to physiologic effects and nomenclature, but recently two factors have been definitely established. One has been isolated and identified as lactoflavin, which occurs in milk and in other foods. The other factor prevents

pellagra in rats and is probably specific as a preventive of that disease. Lactoflavin will neither prevent nor cure pellagra in rats, nor is it effective in the treatment of pellagra in man (fig. 5).



Lactoflavin
[6,7-dimethyl-9-(d-1′-ribityl)-isoalloxazine]

Lactoflavin + H_3PO_4 ⟶ Phosphoflavin
Phosphoflavin + Protein ⟶ Flavoprotein (Enzyme)

Hemin + Globin ⟶ Hemoglobin

Hemin + Specific protein ⟶ Hemoprotein (Catalase)

FIG. 5

Lactoflavin is a complex nitrogen-containing compound with a carbohydrate side chain which is derived from the five-carbon sugar d-ribose. The physiologic rôle of this vitamin is very interesting. The animal body requres the vitamin for the synthesis of what are known as "flavoproteins." Phosphoric acid is attached to the carbohydrate chain at a point which is unknown, and the phosphoflavin then combines with protein in a manner similar to the combination of hemin with globin to form hemoglobin. The flavoprotein which results is an enzyme which functions as an intermediary catalyst in cellular oxidations. These relations are shown in figure 5.

In addition to lactoflavin there are many other flavins. Hepatoflavin, uroflavin, ovoflavin and a yeast flavin have been identified. It is not yet known whether these are different or are all the same substance, although it can be stated that hepatoflavin has a vitamin activity identical to that of lactoflavin.

Last in the alphabetical list is vitamin E. It has very recently been isolated, but very little beyond the empirical formula is known. Its formula is $C_{29}H_{50}O_2$ and it is an alcohol. It has been named "α-tocopherol."

Vitamin E is essential for maintenance of the reproductive function in both males and females. The possibility of a lack of this vitamin in the ordinary diet is rather remote.

This summary of our present knowledge of the vitamins has been confined to the more common ones, since they are well characterized and considerable knowledge of them has been accumulated. Not so well known are several other vitamins which, although well defined as accessory food factors, cannot yet be described in chemical terms but only in terms of pathologic conditions which develop when they are lacking in the diet.

TEACHER, WHAT'S YOUR ANSWER?

By CHARLES H. STONE, *Boston*

What provision do you make in the laboratory for the bright student who can do all the required work in half the allotted time and who wants something special to do?

Do you encourage your better pupils to do this extra work along some line of personal interest? Why?

Do you encourage your better pupils to prepare exhibits of their work?

What type of laboratory note book do you favor? Why?

How do you handle the dull pupil who gets far behind in his work?

How do you prevent copying of note books in the laboratory?

How do you prevent "fooling" in the laboratory? And how do you prevent individuals from trying original experiments just to "see what will happen?"

Do you require drawings of apparatus in the note books? Why?

Do you provide dilute acids for student use or do you have them prepare their own? What advantage in the method you use?

How do you try to prevent waste of chemicals in the laboratory?

Have you ever had an "open house night" at your school? Why?

Do you permit the pupils to handle: yellow phosphorus, sodium, bromine, hydrofluoric acid, or to make carbon monoxide? Why?

Do you have an occasional inspection of lockers to see that pupils are keeping them reasonably neat?

Do you ever give out the last key to a locker to a student who has lost the previous one?

How do you prevent breakage in the laboratory, or how do you attempt to keep it as low as possible?

Is there a laboratory fee in your school? Why?

Are you reading some good educational magazine? Are you contributing to one? Why?

VENICE BOAT TAXIS

A fleet of taxicabs in Venice is a real fleet. The city now has an organized water taxi service consisting of 33 motor launches, to ply up and down the famous Venetian canals.

IN A SOUND STUDIO

An Auditorium Program by the Physics Class

By B. S. Whitmore

Greencastle High School, Greencastle, Pennsylvania

The following is the script of an original assembly program recently presented by the physics class of our local high school. The fact that half the class were members of the orchestra suggested the possibility of a program featuring both the scientific and artistic aspects of sound and music. This proved to be a happy thought, for our presentation was voted one of the most popular numbers of the year. Such a program, arranged with the assistance of the music department, will do much to create respect for the work in music appreciation and to increase the popularity of that rather mysteriously mathematical subject of physics.

The material here presented can readily be adapted to the equipment and personnel of any high school. If scientific detail seems to have been slighted a bit, remember this has been done to accelerate the platform presentation. Specific assignments must be made for the various demonstrations, and careful preparation and rehearsal are essential to success.

SCENE

SOUND STUDIO OF SIGNOR SONORITA

(*Small lecture table center. Physical demonstrations right center. Orchestral equipment with piano center. Broadcasting studio left center. Class on stage. Curtains closed. Announcements and certain of the sound effects are given through the school's radio or amplifying system.*)

PROGRAM

(*Cymbal Crash.*)

Announcer: Presenting: "Some Sound Effects" from Signor Sonorita's Sound Studio. This program by the class in physics, in collaboration with the Ben Franklin Electrical Club. Stand by for the opening number.

Overture: "The Voice of Thunder"—Ensemble

(*Ensemble plays short descriptive number with "storm effects."*)

(Billy Hill *and* Happy Hiram *enter from left and right.* Billy H. *dressed as awkward "hill billy" and carrying a guitar.*

HAPPY H. *as a country fiddler—fiddle in sack. They meet in center and look about inquiringly.*)

BILLY H.: Howdy, stranger. Can you tell me where to find —(*Reads from card.*) Sig—nor Sounder, the music man hereabouts? I just got me a gitar and he says he can learn me in ten lessons guaranteed.

HAPPY H.: (*Discovering large sign center.*) I reckon this be the place. (*Indicates sign.*) My gal's went and took up with one of them slippery saxyphone fellers, and now she says my fiddle's "pas-say." Just you wait till I get my tech-ni-que fixed up, and she'll think I'm a vilin player from the oprey. (*Reads*) "SIGNOR SONORITA'S SOUND STUDIO—Ring the bell." (*Pulls rope and big bell back-stage rings.* BILLY H. *and* HAPPY H. *register surprise. Curtains part discovering a lecture in progress.*)

SIGNOR SONORITA: Welcome, Signors. You wish to matriculate in our institution?

HAPPY H.: No, we just want a couple o' lessons on these here instruments of torture.

SIGNOR: Very well, just be seated. We can arrange later. (*Resumes*) As I was just saying, gentlemen, sound is something perceived by the ear and interpreted by the brain. (*Applies match to a small gas-filled balloon.*) When I do this every ear in the room is conscious of a shock which we call sound. When we observe all such sounding bodies, we perceive that they are in rapid vibration. (*"Break" on trumpet, saxophone, and drum.*) When we strike the tuning fork and place it on the table, you hear a characteristic sound (*Demonstrates fork*) but you see no vibration. However, when we hold it near the suspended cork ball, the ball is set in perceptible motion. (*Demonstrates fork and ball.*) But, you ask me, how is this vibration transmitted; how does it register on the distant eardrum? Does the air move from here to there? (*Gesture*) No, the air does not move; rather —shall I say? it is the motion that moves. Let me illustrate: My assistant makes a sharp sound at the other end of this tube and the electric lamp is extinguished. (*Demonstrates large tube fitted with diaphragm and magnetic contact to work relay.*) Evidently a vibration passed through the tube with sufficient force to operate a relay in contact with the diaphragm at the end of the tube.

For another illustration I shall call upon five young gentlemen to assist. (*They line up.*) I designate them as air particles A, B, C, D, and E. I give A a slight push (*Pushes—pauses*) and an

impulse moves through the line and strikes the drum. Such an impulse moving from particle to particle we call a sound wave.

SMART STUDENT: But, Professor, suppose there is nothing to wave?

SIGNOR: Ah, yes! Wave motion is a vast and comprehensive subject—water waves, air waves, ether waves, radio waves, permanent waves, and—yes, yes, there must be a medium to wave. When we ring this bell in the open air you hear it distinctly. (*Demonstrates bell in air.*) But when we place it on the air pump and exhaust the air, you hear it faintly or not at all. (*Demonstrates bell in vacuo.*)

BILLY H.: How fast does sound travel, may I ask? I often see the smoke from pappy's gun before I hear the bang.

SIGNOR: That varies. About 1,100 feet per second in air, 4 times as fast in water, and about 10 to 15 times as fast in metals. It increases with the elasticity and decreases with the density.

STUDENT: I see, that's why some of us are so slow on the pick-up.

HAPPY H.: Signor, what's an echo? Sometimes when I shout "Hello!" down the well or out by the barn, a sound comes back and says, "Hello, yourself!" They say that's an echo.

SIGNOR: Well, according to the ancient Greeks, Echo is a beautiful lady who has lost everything but her voice, and has been doomed to live forever in the woods and glens. She can't begin a conversation but she always has the last word. She was enamored of a beautiful youth named Narcissus. When he shouted, "Dost thou love me?" Echo answered, (GIRL'S VOICE *off stage:* "Love me.") and when he pleaded, "Wilt thou have me?", Echo responded, (GIRL'S VOICE *off stage:* "Have me.") (HAPPY H. *makes a break for the "Echo"; others restrain him.*) This romantic phenomenon is caused by the reflection of sound from a smooth surface sufficiently distant—at least 55 feet—to produce a separate and distinct iteration of the original. The effect produced by this reflection we notice especially in an empty building. We do not notice it when an audience is assembled because an audience is a good absorber of sound. You see how this audience is absorbing the sounds we make. Sometimes a sound echoes and re-echoes as is apparent in an archway or in a deep cavern. This effect we call reverberation. (*Tosses large tin can off stage right. It "bump-bumps" down the steps and rolls on (?) at left.*)

(*Sudden crash back-stage*)

CLASS (*Starting*): What was the noise?

SIGNOR: You ask what the noise is, eh? Noise is an irregular series of shocks that gives a jolt to the auditory nerve, while a musical sound flows smoothly and with unerring regularity. If we can make the blows and taps and puffs regular and rapid enough, we have a musical tone. Friction is always rhythmic. When a resined bow is drawn across the strings, the tension of the string secures perfect rhythm of the friction. (*Violin demonstrates.*) The rifle bullet sings in the air, (*Song whistle*) and the wind against the boles and branches makes the mournful music of the pine woods. (*Wind machine*). We speak of the musical drip of the water, and even a flame will break into a rhythmic flutter, and if placed in a tube of proper length, will burst forth into song. (*Demonstrates singing flame.*)

These musical sounds differ in pitch, in loudness, and in quality.

Pitch is perhaps the most prominent characteristic of sound. The piccolo produces tones of high pitch (*Piccolo*): the saxophone, tones of low pitch (*Saxophone*). A tune is only a string of notes of different pitch. Pitch depends on the number of vibrations per second. If we blow a stream of air into a revolving siren, we note, first, a series of puffs that blend into a tone of rising pitch as the speed is increased. (*Demonstrates siren.*) All tones of the same pitch therefore have the same speed of vibration. When we tune our instruments to "A" of the piano, or oboe of the orchestra, we bring them all to a rate of 440 (*Musician's Standard*) vibrations per second. (*Orchestra sounds the "A."*)

Loudness or intensity—measured now in decibels—is largely a question of energy. (*Bass drummer demonstrates.*)

In musical instruments, it is customary to gain intensity of tone by making use of the principle of resonance. The sound box of the violins or the air passages of the wind instruments may be set in vibration sympathetically, thus reinforcing the tones corresponding to their free periods. To illustrate:—If we hold a vibrating tuning fork above the vertical glass tube A, no sound can be heard from it; but when we place it above the tube B, which has been adjusted to reinforce the sound of the fork, we hear it distinctly. In like manner, the various types of resonators used on string and wind instruments have a profound effect on the volume and tone quality of the instrument. (*Demonstrates glass resonance tubes arranged as suggested.*)

Quality or tone-structure is the most elusive and distinctive feature of a tone. It is that which enables us to trace a sound to its source. We distinguish at once the sound of the horn from that of the piano. (*Horn and piano play a bit of melody.*) Quality is that which produces the delightful variety of tone color which even the average ear is able to recognize but not analyze, for this tone color depends on a complexity of vibration too involved to be attempted here.

Now that we are considering the characteristics of music, suppose we invoke the Spirit of Music and ask her to show us some of the mysterious magic of the music makers. (*Ensemble plays "entrance music" and the* SPIRIT OF MUSIC *skips downstage, directing with her baton. The* "SPIRIT" *might be dressed in the drum major's regalia, or wear a black and white crepe paper costume with high hat, all liberally decorated with notes and bars.*

SPIRIT OF MUSIC:—

"Music is made
By rules architectural, rules mathematical;
Then wisely interpreted, daintily played,
It touches emotions quite childlike and primitive."—West

Music expresses these deep feelings of life through three elements. Sometimes it is just the flow of rhythm, (*Drummer illustrates.*) or the golden thread of melody, (*Any solo instrument.*) or fascinating harmony. (*Piano or ensemble illustrates.*) To speak this universal language a musical instrument must have:

1. A means to produce the tone.
2. A way to vary the pitch.
3. A means to amplify and regulate the volume.

Nearly all musical instruments may be classed either as stringed or wind instruments. Since we have here a good representation of these types, let us take a look into the soul of the violin or the brazen throat of the trumpet. First, the violin. (*Violin player rises.*) The violin is the most important instrument of the orchestra; it has been called "the prima donna" of the string choir. The tone is produced by the friction of the bow on the strings while the fingers press the strings to change the pitch. (*Violinist runs a scale.*) These vibrations are carried to the body of the instrument which vibrates and produces that rich, soulful sonority of the violin. Each string has its own characteristic voice: The E string—sharp and clear—is used to play the melody, (*Player demonstrates each string.*) the A and D strings are soft, beautiful, and melodious,—while the G gives a

rich resonant tone, harsh and strident in some passages. But listen—(*Violin solo*).

FIRST STUDENT: What do you think of our violinist's execution?

SECOND STUDENT: Well, I'm in favor of it.

SPIRIT OF MUSIC: Sometimes stringed instruments are played by plucking instead of bowing. Perhaps our young friends from the hill country will demonstrate. (*They consent, strike a few chords, then—*)

SPIRIT OF MUSIC: Presenting: "The fiddle and gitar!" (*They play "Turkey in the Straw" or other lively tune.*)

SMART STUDENT: Say, do you fellows ever play anything by request?

BILLY H. and HAPPY H.: Sure. Be glad to.

SMART STUDENT: Then how about playing dominoes a while?

SPIRIT OF MUSIC: The wind instruments produce a tone by the forced vibration of a column of air. Take the flute as a common type. (*Flute player rises.*) Here we have a straight tube of wood or metal, a miniature organ pipe, pierced with a hole for a mouthpiece through which the lips of the player start the vibration. The tube is shortened or lengthened by covering or uncovering a series of holes, thus changing the pitch. The flute is one of the oldest and best known of the wind instruments. Its clear and thrilling notes suggest the vaulting tones of the coloratura soprano. In the symphony we hear how its birdlike voice is used to color and embellish the melody. (*Flute solo or obligato.*)

The clarinet is perhaps the most useful member of the woodwinds. (*Clarinet player rises.*) Here the tone is produced with a flat reed fastened to a tapered mouthpiece. It has four distinct registers of tone: (Player demonstrates each register.)

1. The lowest—intonation hollow and reedy.
2. Second—not often used.
3. Middle—of reedy sweetness, much used for solo.
4. Highest—flutelike in quality.

Clarinets are made in different keys. Most popular is the B-flat. Let us hear it. (*Clarinet solo.*)

Some years ago Joseph Saxe put a clarinet mouthpiece on a brass instrument, and lo, we have a saxophone. The modern jazz band has bred a whole brood of them. (*A little "Saxophobia," selected.*)

THIRD STUDENT: Why did Bill take up the big sax?

FOURTH STUDENT: Guess he thought he'd have more sax appeal.

SPIRIT OF MUSIC: When the average person says "horn" he has in mind some instrument of the trumpet type in which the tone is produced by vibrating the lips against a cup-shaped mouthpiece. In fact the first trumpet was a ram's horn or something similar. For a long time little change was made in the trumpet except to wind it up for convenience. (Here an old dinner horn or coach horn will be unique.) The overtones of the bugle produced by a change of lip pressure give a sufficient repertoire to rouse the soldier from bed—(*Bugle blows "Reveille."*) to call him to duty—("*Assembly*") and to lull him to rest at night—("*Taps*"). To the original trumpet have been added valves, and pistons, and pipes, so that in the modern trumpet, horn, and tuba the "music goes down and around" and a complete chromatic scale is possible. (*Trumpet player does some scales and cadenzas.*) The tone of the trumpet is rich and brilliant in FF and smooth and beautiful in PP. (*Cornet solo or duet.*)

The mellow horn we usually associate with the gay hunting party, but today it vies with the trumpet for popularity in the orchestra, for its tone is majestic, passionate, tender, solemn. Hark to the horn! (*Horn solo.*)

All members of the brass family are built on the same general plan except the trombone in which the pitch is regulated by telescoping tubes which make possible a perfect scale and a gliding effect from tone to tone. Hear the stately sonority of the trombone! (*Trombone novelty.*)

The largest member of the horn family is the tuba that "Juba played way down in Cuba." It is the "Um-pah! Um-pah!" horn of the brass band. Most of us call it the big bass horn. Its tones are full and rich, similar to those of the big organ pipes. (*Tuba player does some "low" comedy, and the Ensemble swings into a "Finale" while the Spirit of Music retires, beating the rhythm.*

Of course these demonstrations will feature the instruments that are available. A "faked" solo, with real performer in the wings continuing after the "soloist" has made his bow, is good for a big laugh.)

OPTIONAL

SIGNOR SONORITA: In the radio to-day we have the last word in sound production, transmission, and amplification; and the

highest achievements in the mechanics of music and its artistic presentation. As a concluding number for our program, the Ben Franklin Electrical Club has arranged a peep into a broadcasting studio, to let us see what goes on at the other end of our radios. Take it away, Ben!

(*At the left of the stage the electrical club presents an amusing take-off on the average radio program: The master of ceremonies takes charge, the orchestra plays the theme song, the cast read their lines into the "mike," the sound man performs, the soprano soloist blows out a tube with a too high note, the drummer does a tap dance on his Chinese drum, and the announcer concludes with the usual station amenities.*)

MAN'S USE OF ROCKS AND MINERALS FROM OUR EARTH

A Fourth Grade Unit

By Illa Podendorf
Supervisor of Elementary Science,
Newton, Iowa

In Newton the grade schools are built on the Platoon System. This system provides that each child spend one-half day in a home room where fundamental subjects such as reading, arithmetic, etc., are taught by a home room teacher. The other half day is divided into five periods of special activities each being taught by specially trained teachers in a well equipped room. Elementary Science is one of these activities. It is given thirty minute periods four days per week.

The following is a brief outline of a fourth grade unit on "Man's Use of Rocks and Minerals from the Earth," which we teach in November:

ROCKS AND MINERALS FROM THE EARTH

Aims of Unit:

1. To realize the whole earth is made up of rocks and minerals.
2. To appreciate their industrial value to man.
3. A recognition of a few of the most common ones.

Presentation of Unit:

Usually one period is spent in exploring the field, finding out what the group has as a foundation, what their interests are, creating the problem and a need for its solution.

Material to be Presented:

I. The difference between a rock and mineral.
   A. Minerals—a natural substance with a definite composition. Example—Quartz—SO_2. One part silicon and two parts oxygen.
   B. Rocks—a natural substance formed from one or more minerals without a definite composition.
      Example—Sand—Clay—Granite.

II. Some of the common rock forming minerals are:
   A. Quartz is most common and makes up about twelve per cent of the earth's crust. Quartz crystal is always a six-sided prism with a six-sided pyramid at each end if it is a perfect crystal.
      1. Varieties of quartz
         (1) Pure quartz—white
         (2) Smoky quartz—brown colored
         (3) Petrified wood—color of wood
         (4) Opal—milky-white
         (5) Nearly all birthstones are forms of quartz.
   B. Calcite—next to quartz in abundance is found in a great variety of forms.
      1. A distinctive characteristic of calcite is its marked property of deflecting light rays, so that a letter or line placed beneath the calcite appears double.
      2. Forms of calcite:
         (1) "Satan Spar"—Niagara Falls
         (2) Stalagmites, Stalactites } Mammoth Cave–Kentucky
         (3) Chalk—Cliffs of England
         (4) Gypsum—for stucco, cement
   C. Talc—a secondary mineral is the result of exposure.
      1. In a very compact form it is called soapstone.
      2. The scaly form is ground for paper, crayons, toilet powders.
   D. Mica is a very common mineral.
      1. Cleaves in sheets.
      2. Used in making radio sets, stoves, car curtains.
   E. Galena is lead ore.
      1. Cleaves in three directions making cubic crystals.
      2. Used in making radio sets.
   F. Asbestos is a fibrous mineral.
      1. Cleaves in fine threads or needles.
      2. Used in various ways to resist heat.

III. Rocks used for building:
   A. Limestone
      1. A mineral formed from the shells of animals that lived ages ago in the ocean.
      2. Is white, gray, green, brown and other shades.
   B. Sandstone.
      1. A rock formed from sand under water and pressure.
      2. More easily weathered than limestone.
   C. Marble
      1. Is limestone which has been changed by heat and pressure to a crystalline rock.
      2. Is white, gray, black, and other shades.
      3. Most of it comes from Vermont.
   D. Granite
      1. Most durable of all building stones.
      2. Found in many colors.

E. Slate
1. Used for roofs of buildings.

IV. Salt—Halite
A. Found in oceans, salt lakes, salt mines and brine springs.
B. Rock salt deposits occur in Michigan, New York, Ohio and Kansas.
C. Used as a seasoner and preserver of food.
D. Value placed upon it is closely associated with man's advance from savage and nomadic conditions of life to those of a higher civilization.
E. To Arab tribes salt signifies friendship.

V. Relation of rocks and minerals to us.
A. The whole earth is made up of rocks and minerals.
1. Foundation upon which we build.
2. The extent to which they are used is a measure of the advance in civilization.
B. The rock and mineral industry ranks high as an industry in the United States.
1. Gives a large production of annual wealth.
2. The United States owes its industrial greatness largely to this industry.
C. Rocks and minerals were formed millions of years ago.
1. By natural agents.
2. The decomposition of rocks has formed soil.
D. The earth's crust has been penetrated to about two miles.
1. Outer portion is rock—may be just one or several minerals pressed together.
2. Rock is covered with soil varying in depth from not any soil to several feet.

VI. Conclusion
A. The whole earth is made of rocks and minerals.
B. They are of great industrial value to man.
C. Man has made use of them all through history.
D. Man is making more use of them now than ever before.

Suggested Activities:

1. Make a class collection of common rocks and minerals as sand, clay, gravel, mica, talc.
2. Make a list of jewelry worn by the pupils in the room which may be some form of a mineral. List the building materials in the building or parts of the furniture as gypsum in the plaster, or iron on the desks.
3. Poster showing uses of rocks and minerals.
4. Test soils for holding water, etc.
5. Individual collections.
6. Electric chart for identification.
7. Games.

FOR SALES APPEAL ONLY

The so-called aircraft trend in automotive design has sales appeal only, charges Ralph H. Upson, aeronautical engineer. Streamlining, states Mr. Upson, is a typical case where the semblance is taken and the substance allowed to go. One constructive idea from aviation is the reduction of the weight of automobiles and the older concept that a car had to be heavy to have easy riding qualities.

TEACHING A UNIT ON THE CHIEF CEREAL CROPS OF THE UNITED STATES*

By Rachel Hunt

Forest Park School, Fort Wayne, Indiana

The chief aim of my teaching is to try to appeal to every child in the group. In other words I consider myself a salesperson for the subject of geography. If I can interest each child in some phase of geography whether it be reading matter, making graphs and charts, or collecting pictures that pertain to the subject at hand, then I have really succeeded in my plan. With this idea in mind I drew up outlines. Some people call them units, others contracts, I call them study guides or outlines. Be what they may, I find that they help me to fulfil my aim of trying to interest every child in the subject of geography.

I find that such outlines may be easily adapted to fast, average, and slow moving groups; for example, I usually require all groups to do all of part one in these outlines, the faster moving groups do nearly all of parts two and three. For the average and slower groups I let the various members choose the things in which they are most interested. In the case of these last mentioned children I have to consider their sources of supplies and materials along with their experiences; for example, in the unit on wheat I have asked, "If you have ever visited a flour mill tell how flour is made." I have always contended that the fast moving child "will learn in spite of the teacher," but the slower moving ones need motivation, sales-talk, or whatever you choose to call it.

I feel that this is especially needed in my teaching, for many of these slower and average children will never study geography again as a special subject, as they will drop out of school before they will have had time to elect it in high school. I hold each member of each group responsible for his assigned or chosen task even though he may find it difficult or his problem does not turn out perfect, for when these children get out in life they will not find every task easy, nor, can they always achieve perfection upon first trial of meticulous duties.

When I begin with these grain crops my opening question is "How many of you have ever lived on a farm?" Then, "How many have ever spent some time on the farm?" I find that only

* Read before the Geography Section of the Central Association of Science and Mathematics Teachers, St. Louis, Nov. 27, 1936.

a few answer no to these questions. This gives me an idea of their first hand knowledge of the farm. I then tell the children that Fort Wayne owes its growth largely to the fact that it is within the great Corn Belt of the United States. We open our books and find the location of the Corn Belt. They are ready to begin a study of this great Corn Belt by extensive reading. Dr. McConnell's book is the text. Other books are used, too, for they are urged to read extensively. They also read the Government bulletins and Purdue bulletins. A few of these children have lived on a farm and they, along with my help, supply knowledge of the corn and wheat farming that is not in our references. (Example, time of planting and harvesting crops around Fort Wayne.) With part one as a study guide the children compile their information of reasons and facts.

In part two the children continue their extensive reading and study, but in addition they illustrate their findings in collections of pictures and show comparisons and contrasts by graphs and charts. It is in this part that they make a review of all the chief corn producing countries of the world. They compare the production of each of these countries with that of the United States by a graph. Part three as I have said before is still more advanced and depends partly upon the experiences of the child. We also go into literature; for example, there is a reference to Whittier's "Corn Song," and this poem was well given by a boy who excels in speech and dramatics, but is not so good in art work. A corn stalk was brought in and a girl gave a good explanation of its parts.

In the wheat study guide I have followed the same general plan. For checks or tests I have used the true-false type, the completion type, and the picture study. The picture tests may be used with any appropriate picture within or without the text; the tests may be oral or written. They are also good to use with slides. Although slides are nowhere mentioned on this outline, much of our illustrative work was done on slides this fall. Some are original, some are not. Each child who did a slide wrote a paragraph explaining the meaning of his work.

There are always many things coming up in class for which there is no plan. Some of these were a bottle of grains of corn and wheat, clippings of the Corn Husking Contest, a small jar of growing wheat, and miniature models of farm machinery from the International Harvester Company in Fort Wayne. These afforded much interesting discussion.

Last year we used Dr. McConnell's lectures from the Ohio School of the Air, but this year, to our great disappointment, he was not on the air.

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HOW WE LIVE AND WORK ON AMERICAN FARMS

Leading grain crops of the United States

CORN

Part I

1. (a) What is our leading cereal crop?
   (b) Write two statements that prove the answer to (a).
2. (a) What is the extent of the Corn Belt in the United States?
   (b) See the maps p. 42, text and list six other countries besides the United States that raise much corn.
3. Name the reasons why there is a Corn Belt.
4. Explain why the Corn Belt soils are so fertile.
5. (a) How much rainfall is needed to make corn grow?
   (b) Why is the rainfall in the Corn Belt especially favorable for growing corn? What is the summer rainfall of the eastern part of Corn Belt? the western part?
6. How do the summer temperatures of the Corn Belt favor corn growing?
7. (a) What is meant by the term "growing season"?
   (b) What is the length of the growing season in the Corn Belt?
   (c) How long a growing season does corn need to ripen?
8. Why is corn sometimes put in silos? Why is there no northern boundary to the Corn Belt?
9. Where is the canning of corn a leading industry? Why do the farmers in that state raise corn for canning rather than for fattening hogs?
10. Name the chief uses of corn.
11. On an outline map shade in the Corn Belt.

Part II

1. Write a paragraph entitled "Natural Conditions That Determine the Boundaries of the Corn Belt."
2. Make a circle graph showing the uses of corn in the United States. Put pictures in the divisions as much as space will permit. Write an explanation of this graph.
3. Collect several pictures for your notebook showing various uses of

corn on farms. Put them in your notebook. Write an explanation of their meaning.
4. Collect several pictures showing different ways in which the grain of corn is used. Explain how each is used.
5. Make a graph showing the leading corn-producing states.
6. Make a graph showing the six chief corn-raising countries of the world.

Part III

1. Bring in a stalk of corn and explain its parts to the class.
2. List several different varieties of corn that are grown in various parts of the country. Get pictures for your notebook to illustrate these varieties.
3. Find pictures of different kinds of machines that are used in plowing, planting, cultivating, and harvesting corn. Write an explanation of why and how farmers are able to use these expensive machines. See p. 47.
4. Read "The Corn Song" by Whittier.
5. Make slides showing scenes in the corn field from plowing time to harvest time.

WHEAT

Part I

1. What per cent of the world's total wheat crop does the United States produce?
2. (a) What states does the greatest wheat belt include?
   (b) What part of our wheat is produced in this belt?
3. Following the outline below write out statements that tell "why wheat thrives in this belt."
   (a) Level plains.
   (b) Fertile soil.
   (c) Temperature and rainfall in early part of growing season.
   (d) Temperature and rainfall in later summer growing season.
   (e) Amount of rainfall.
4. Write a paragraph entitled "Winter wheat." Follow this outline. (a) When sown (b) When harvested (c) Where produced (d) Why limited to this area.
5. When is spring wheat planted? What state leads in producing spring wheat? List two reasons why spring wheat can be produced so far north. Why is the Valley of the Red River of the North so famous for spring wheat?
6. For what is hard wheat used? soft wheat?
7. Why is durum wheat grown in dry regions? Where was it formerly grown? For what is it used? Why?
8. On an outline map shade in the winter wheat belt and the spring wheat belt.

Part II

1. List at least six great wheat growing countries of the world besides the United States.
2. Wheat is harvested somewhere in the world all the year round. Prove this statement.
3. Today much of the work on American wheat farms is done by machinery. Why is this true?
4. Make a graph showing the six leading wheat producing countries.

5. Collect pictures for your notebook showing several products made from wheat. Write a statement telling the one chief use of wheat.

Part III

1. Make a graph showing the six leading wheat producing states.
2. Collect for your notebook pictures of machines used in producing wheat, elevators, and wheat being transported to market. Explain what work each machine does.
3. List the chief flour milling cities and the chief wheat exporting ports.
4. If you have ever visited a flour mill tell how flour is made.
5. Make pictures of our work on wheat for slides.

TEST OVER CORN

In front of true statements write T. In front of false statements write F.

_____ 1. Corn needs frequent rain during the growing season.
_____ 2. Corn was well suited to pioneer farming because it required less labor than other crops, and it yielded a large amount of food for people as well as food for farm animals.
_____ 3. Corn grows and produces best in regions of cool cloudy rainy summers.
_____ 4. Corn needs much rain during the harvest season of Oct. Nov. & Dec.
_____ 5. The Corn Belt does extend farther south because it is more profitable to grow cotton and the summers are so long that the corn goes to stalk.

Fill the blanks below with the word or words that give the statements the correct meaning.

6. Some corn is produced in every state, but nearly two-thirds of it is grown in the region known as the .....
7. The growing season of the Corn Belt ranges from .... and .....
8. The state that grows the most corn for canning is .....
9. The leading corn producing state is.....
10. Much of the green corn on the northern edge of the Corn Belt is put in ..... for feed for dairy cattle.
11. The Corn Belt does not extend farther west because it is too..... .....
12. The three chief corn producing states in order of importance are ....., ..., and .....
13. What conditions of each of the following favor the growing of corn on the Corn Belt?
    a. soil c. rainfall e. temperature
    b. surface d. growing season
14. The term growing season means from the ..... to .....

TEST OVER WHEAT

In front of true statements mark T. In front of false statements mark F.

_____ 1. Wheat requires more moisture than corn.
_____ 2. In the leading wheat producing states much of the work on the farms is done by machinery.
_____ 3. The Mediterranean type of climate is favorable for wheat but unfavorable for corn.
_____ 4. Level land and a fertile soil have helped make the valley of the

Red River of North Dakota and Minnesota famous for spring wheat.

_____ 5. The wheat harvest season needs to be cool and moist.

Fill the blanks with the word or words to make the statements correct.

6. Winter wheat is sown in .....
7. Spring wheat is sown in .....
8. The chief winter wheat producing state is .....
9. The chief spring wheat producing state is .....
10. Durum wheat was brought to this country from .... because .....
11. Durum wheat is used for making ..... because ....
12. Hard wheat is used for making .....
13. Soft wheat is used for making .....
14. Two reasons why spring wheat grows rapidly and ripens during its short growing season are: because ..... and .....
15. Winter wheat is harvested during ..... and .....
16. Name the three chief wheat producing states ...., and .....
17. The term "growing season" means from ..... to the .....

PICTURE TESTS

Test Over Corn

McConnell: The United States in the Modern World
Turn to page 34, figure 50

1. In what great cereal producing region was this picture taken?
   What advantages does it have for producing corn?
2. At what time of year was this picture taken?
3. When was this corn planted?
4. During what season will the farmer harvest this corn?
   Over how long a period will the harvesting extend?
   What advantages does this season offer for corn harvesting?
5. Explain at least one method that the farmer might use in harvesting this corn.
6. How is the surface an advantage to the farmer in planting, cultivating and harvesting this corn?
7. In what form will the farmer likely market this corn?
   In what great city might this market be?

Test Over Wheat

Turn to page 37, figure 56.

1. At what time of year was this picture taken?
2. What is this machine that the men are using?
   How does it help the wheat farmer?
3. In which wheat belt are these farmers working?
4. When was this wheat sown?
5. At what large nearby flour milling center will it find a market?
6. How does the surface enable the use of such a large machine?
7. Compare the time that it took to produce a bushel of wheat in 1830 with that in 1930.
8. What kind of weather do you think they are having?
   Is it an advantage or disadvantage? Why?

THE STORY OF NATURE EDUCATION IN WORCESTER, MASSACHUSETTS

By William Gould Vinal
Nature Specialist
National Recreation Association

Worcester, Massachusetts, one of the cradles of Nature Education, has a notable lineage of backers of the movement. The story, too often overshadowed by Bostonese loomings, has a right to stand on its own merit and is herewith presented for its face value.

The first settlement called Quinsigamond (1673) was abandoned during King Philip's War. The second settlement (1684) was also abandoned because of marauding Indians. A permanent settlement was made in 1713. Jonas Rice, the first permanent settler, built his home that year and on April 4, 1726 he was voted the village school master. In 1731 the selectmen were instructed to obtain "school dames" to teach the five district schools.

In 1755 John Adams, the second President of the United States, graduated from Harvard and came to teach in the first school house in Worcester (1755–1758). In 1756 he wrote in his diary, "But I have no books, no time, no funds; I must therefore be contented to live and die an ignorant, and obscure, fellow." With him, as with other young men of his day, teaching was a stepping stone to becoming a clergyman, a doctor, or a lawyer. Adams chose the latter.

John Adams' school was ungraded. The intellectual food of his pupils came from learning the alphabet, reading the Bible, the New England Primer, and the Hornbooks. In a letter to Judge Richard Cranch of Boston (September 2, 1755) the young school master gave an account of the situation. "Sometimes paper, sometimes his penknife, now birch, now arithmetic, now a ferule, then A, B, C, then scolding, then flattering, then thwacking calls for the pedagogical attention." On March 15, 1756 he referred to his school as a commonwealth. "I have others catching and dissecting flies, accumulating remarkable pebbles, cockle shells, etc., with as ardent curiosity as any virtuoso in the Royal Society. Some rattle and thunder out A, B, C, etc., with as much fire and impetuosity as Alexander fought." Adams was comforted by Dr. Savil as follows: "By

cultivating and pruning these tender plants in the garden of Worcester, I shall make some of these, plants of renown and Cedars of Lebanon." Adams retorted by saying however, "I am certain that keeping this school any length of time would make a base weed and ignoble shrub of me." All of this thinking and philosophizing is typical of the period of *sacred* natural history.

Poor Richard's Almanack (1732–1757) commonly sold up to 10,000 copies annually. "As poor Richard says" became a household phrase which gave weight to any counsel on thrift. Then came Thomas's New England Almanack. Isaiah Thomas (1749–1831) published the New England Almanack (1775–1822) for forty-two years. He had declared opposition to the Stamp Act, and three days before the battle of Lexington, at the suggestion of patriots, he moved his free press to Worcester. He printed several editions of the Bible, the *New England Primer*, and *Travels of Robinson Crusoe*. Isaiah Thomas was the leading publisher of the day. He published over a hundred children's books. His first *Mother Goose's Melody* (1786) was the most famous. He ended each ditty with a maxim. Hickory, Dickory, Dock closed with "Time waits for no man." These stories taught the virtues—honesty, courage, diligence, etc.

Human errors of the day (1787) were commented upon as follows:

> Here two naughty boys
> Hard-hearted in jest
> Deprive a poor bird
> Of her young and her nest.

Boston culture, from the "hub of the Universe," justly or unjustly, overshadowed Providence and Worcester. This included nature culture as well as music and art. Many of the progressive ideas came from Harvard University. Edward Everett Hale (1822–1909) entered Harvard at the age of thirteen. For those unacquainted with Unitarianism it may be difficult to think of a minister of the gospel preaching in Worcester (1846–1857) and simultaneously becoming the first chairman of the Natural History Department (1854) of the Young Men's Library Association. Yet the early start of nature culture in Worcester was largely due to the liberalism of Unitarians. In a remarkable letter to the editor of the *Worcester Telegram* on March 7, 1905, which was reprinted in the *Worcester Magazine* in June of that year, Doctor Hale wrote as follows: "My interest in botany and in mineralogy was quite in proportion to

my ignorance and I greatly valued the frequent conference brought about by the society with so many who knew more."

On October 24, 1854 Louis Agassiz came by invitation and examined the collections of the Worcester Lyceum of Natural History (1825) which were in the rooms of the Antiquarian Society. Doctor Hale took down in shorthand the suggestions made by Agassiz and comments on the report as follows: "The suggestions it makes as to the value of honest observations made by straightforward working and listening, by people who are not book learned, may have seemed at that time chimerical. But they have been made good and more than good, in the experience of those who carry on the society in its work of today." Any society on the verge of becoming defunct might listen to Doctor Hale. "If the collection be all the members have to think of, they soon exhaust the superficial resources of the flora and fauna and the mineralogy of the neighborhood, and the society dies because it had nothing to do you know."

Doctor Hale could have been describing certain summer camps in 1936 instead of in 1905, when he said that, "There may be left obscure corners where a poor wretched, neglected child is made to 'learn Botany' in 13 weeks—but even in these places there is an echo which tells child and teacher that there is a more excellent way." He might have been addressing the cloistered scientist of today when he wrote about scientists of repute visiting the Quincy quarries for two generations "but a visit by an intelligent physician to the house of an intelligent workman revealed one day the existence of a collection of those fossils, which has been known for twenty years to the man who handled the stones in their daily industry; if only the 'scientists' had taken pains to consult them."

It is interesting to note that the first course of scientific lectures sponsored by the Natural History Society was given at Washburn Hall in 1863. Professor William Denton gave six lectures on Geology. Darwin's *Origin of Species* (1859) had upset the idea of special creation and people now had time to think rather than to quote and preach.

Thomas Wentworth Higginson (1823–1911) was a friend of Rev. Edward Everett Hale and also helped to organize the Natural History Society. His papers on outdoor life such as "The Life of Birds," "The Procession of the Flowers," "Water Lilies," "My Outdoor Study," were all based on scenes in the vicinity of Worcester.

Another nationally-known figure who took part in the early days of the Worcester Lyceum and Natural History Association was the Hon. George Frisbie Hoar (1826–1904) who was United States Senator for 27 years up to the time of his death. Senator Hoar was at one time corresponding secretary of the society and in 1856 he was elected president.

By delving into local annals one makes interesting discoveries. The writer appreciates the opportunity of travel that has come to him and also the privilege of presenting this data to interested naturalists. If enough of these findings are brought to light it will make a valuable basis for the interpretation of the nature study movement. Most of us know that Agassiz made American nature study popular, and we are familiar with the fact that this work emanated from Harvard, but that John Adams was a country school teacher, that Rev. Edward Everett Hale was the father of a natural history society, and that Senator Hoar was its president, is not so commonly known.

It is also of interest to note that the early physicians of Worcester were not only interested in the art of healing, but also in the affairs of progress. Many doctors were naturalists. Dr. Elijah Dix lived from 1771–1795 on Court Hill. He planted elms on Main Street, and created the Dix pear. The old Administration Building of the Ladies' Collegiate Institute was erected in 1845 by Dr. Calvin Newton who conducted a Botanico-Medical College. In 1869 this building was purchased by Worcester Academy. In 1846 Dr. John Green, who received his M.D. degree from Harvard, resolved to lay out Harvard Street parallel to Main and on the crest of the hill. "It would cut into good pasture land, and by its creation and the making of other new ways, coasting surface in the winter and strawberry meadows in the summer would be lost; but it was ever thus that the ideal and ornamental have had to yield to the homely and sordid."[1]

For a hundred and fifty years the boys and girls of Worcester learned nature study on the farm. The farmer plowed, as did Nebuchadnezzar, with a home-made plow. He seldom used fertilizers, cut his grain with a sickle, and flailed the wheat or tramped it out by the feet of cattle. The miles of stone walls are now monuments to the untiring efforts of the pioneer, and his oxen which were ruled by "Haw" and "Gee." Chores con-

[1] "Twenty Years of Harvard Street," by Hon. A. S. Roe, Proceedings Worcester Society of Antiquity, 1896.

sisted of bringing in the wood, picking up the eggs, watering the few neat cattle and feeding the swine. Perhaps the girl churned the butter, held the skein, and dipped the candles. All of these were essentially nature activities. This was rural Worcester.

Then came the urbanizing of Worcester. The members of the Natural History Society were still busy "species hunting." Joseph Jackson, Principal of the Woodland Street School, prepared his first "Catalogue of the Flowering Plants and Ferns" of Worcester County, Massachusetts (1883). It consisted of 812 species, and in 1894 the second edition had 1098 species. In 1878 Edward Howe Forbush (1858–1929) was known as a local taxidermist. In the annual report for that year of the Worcester Lyceum and Natural History Association can be found a report by young Forbush, Curator of the Department of Ornithology, that he "dusted and cleaned the 428 specimens." At the field meeting of the society April 16, 1885, at what was called the new Natural History Park on Lake Quinsigamond, he gave a report of birds seen that day and described the common crow as "not an unmitigated evil." His Worcester apprenticeship was basic preparation for his 35 years as State Ornithologist (1893–1928) and authorship of the "Birds of Massachusetts," with illustrations in color by Louis Agassiz Fuertes and Allan Brooks. The Edward Howe Forbush Sanctuary in the Berkshire Hills is a fitting memorial made possible by the New England Federation of Bird Clubs. The writer enjoyed sailing excursions to band night herons with this genial and eminent ornithologist.

Dr. William H. Raymenton in 1880 was elected president of the Worcester Natural History Society. It was through his initiative and progressive spirit that the societies camp for boys was established on Lake Quinsigamond (1885–1912). The program was a combination of study, work and play, but with more freedom than the so-called Platoon School of today. The leaders followed the immortal advice of Agassiz to "Study nature, not books," consequently there were no text books, but observation lessons and trips were conducted daily. Amateur photography was presented and the whole opportunity was available to boys at $5.00 a week during July and August. The first summer there were 70 boys who must have explored more than the four acres of Natural History Park. The camp was also opened for the special use of teachers in 1905. It is a pity that such pioneer work had to be discontinued because of financial

difficulties. It is also to be regretted that city planning did not start soon enough to make the shores of Quinsigamond a reservation accessible to the public for all time.

The history of nature education in Worcester would not be complete without telling about the great contribution of the school leaders. Professor William Russell established the New England Normal Institute May 11, 1853, for the training of teachers. The fact that such men as Dana P. Colburn, who became principal of the Rhode Island Normal School, Lowell Mason, and S. S. Green (who later went to Brown University) gave courses assured a goodly amount of nature study according to the plan of Pestalozzi and Froebel.

There was a corps of school masters who were not only sympathetic with the nature movement but ardent supporters. We have already mentioned Joseph Jackson. J. Chauncey Lyford, Principal of the Winslow Street School, in speaking at the field meeting of the Worcester Natural History Society at Lake Quinsigamond, April 1885, said what would be timely today. "It is easy to give boys advice, to find work for them to do, to give them a set of rules to guide them through life, but to find some profitable pastime, so captivating that the boys will jump at it with eagerness, is quite a different matter, and in the city especially it is quite a weighty one. It is the demon of 'nothing to do' which kills our city boys." Joseph H. Perry (1858–1934) graduated from Amherst in 1882 and for 47 years taught geology and chemistry in the Worcester High School. His work as assistant geologist under Professor B. K. Emerson enabled him to write treatises on the "Physical Geography of Worcester" and the "Geology of Worcester" 1803. Mr. Perry had a hobby of raising flowers.

Several years ago the writer had the pleasure of visiting the nature classes of Arabella H. Tucker at the Worcester State Normal. Her book on the "Trees of Worcester" (1894) is dedicated "to my teacher and friend, E. Harlow Russell." Miss Tucker describes 161 species, 70 of which were "introduced." She discovered in Worcester 90% of the trees native to the state as listed by Emerson in his "Report on Trees and Shrubs of Massachusetts" and says that up to 1862 when the Commission of Shade Trees was created "all street tree-planting was the result of individual effort, and it is to the labors of such men as Jaques, Colton, Salisbury" etc.

Dr. G. Stanley Hall (1844–1924), president of Clark Uni-

versity (1888–1920) had this to say in the *Worcester Magazine* for June 1905, p. 119: "The time has now happily passed when it is necessary to urge the importance of the love and study of nature or to show how from it has sprung love of art, science and religion, or how in the ideal school it will have a central place, slowly subordinating most other branches of study as formal and accessory, while it remains substantial. To know nature and man is the sum of earthly knowledge."

How could such a forceful statement for the cause come from such an eminent authority? If we look into the background of G. Stanley Hall, we find that he grew up on a farm. His childhood activities were haying, harvesting, driving cattle, hunting, fishing, tramping, and camping, a liberal nature education for any boy. He entered Williams in the class of 1867 under the presidency of Mark Hopkins. As in the days of John Adams, science at College was at a low ebb, and Hall gave his probable profession as the Ministry. Upon graduating from the Union Theological Seminary, Henry Ward Beecher commended the young man for his honesty when he answered that there was more in the creed that he disbelieved than that he believed. His trial sermon was so heterodox that President Skinner instead of giving the usual criticism offered a prayer in his behalf. Hall did not "turn Unitarian" for fear of wounding his mother. His first professorship was that of English Literature at Antioch (1872–1876). While there he made occasional Sunday trips to St. Louis to catch inspiration from William T. Harris. He soaked himself with Darwin, Spencer and Huxley. Although more of interest than of omen, the first year he slept in the room and bed in which Horace Mann died. At Harvard, where he received his doctor's degree in 1878, he tramped and camped with William James.

G. Stanley Hall gave a paper before the American Antiquarian Society in 1890 entitled "Boy Life in a Massachusetts Country Town Thirty Years Ago." This paper is interesting reading and was a prophecy of the program offered by the best camps of today. He refers to Ashfield, Massachusetts, a typical Worcester County town, where he had spent many summers and as a hobby had collected farm tools and household furniture. "This life at its best appears to me to have constituted about the best educational environment for boys at a certain stage of their development ever realized in history, combining physical, industrial, technical with civil and religious elements

in wise proportions and pedagogic objectivity." And in referring to his own boyhood says, "We made collections however for whole seasons, of heads, legs, wings, and tails, as well as of woods, leaves, flowers, stones, bugs, butterflies, etc."

Clifton F. Hodge, co-author with Jean Dawson (who later became Mrs. Hodge) in the writing of "Civic Biology," a book unparalleled in its practicability, was possibly Worcester's outstanding nature teacher. In a letter dated May 11, 1905 to Dr. W. H. Raymenton, which was published in the *Worcester Magazine* for June 1905, he made this significant statement, "What we need more than anything else to counteract the shallowness and artificiality of so much of our modern life is a genuine revival of interest and love of nature. I use the word 'revival' in its religious sense on account of the deep significance of this side of life."

E. Harlow Russell, Principal of the State Normal School, had this to say on the same occasion, the felicitation of the Worcester Natural History Society. "With the greatly increased attention now given in the public schools to 'Nature Study,' as well as to science in general, there is more need than ever before of such aid as this society was organized to afford to a large and an increasing class of people."

The present Curator, Harry C. Parker, came from the University of Kansas in 1930. His youth, energy and enthusiasm guarantee the same high quality of work for the Museum that has characterized it in the past. He should be given worthy support. The City of Buffalo appropriates $100,000 yearly for its Museum and a new building was put up through public bond issue of $1,000,000 and the city provided a site in Humboldt Park. Worcester would do well to invest a goodly sum in its Museum. To date, the Nature Study Movement in Worcester Parks must be credited more to far-seeing individuals than to the Park Board. The "Common" or City Square is an acre of ground which has witnessed the city grow and has successively been a training field, cattle pound, "County Gallows," tulip garden, monument square, and soap box auditorium.

Up to this time the writer has seen but one park—that being Boynton. There are no signs to point the way to the park and its neighbors are utterly unconscious of the existence of a Boynton Park. To make a fire in the open air it is necessary to obtain a Forest Warden's permit, this being a law of the Commonwealth of Massachusetts. Upon entering the park, the

characteristic work of the W.P.A. is evident. Fortunately, they left the mountain laurel, but the berry producing shrubs and undergrowth necessary for bird life has been completely eliminated. The water used is from a brook. There is no instruction offered for the prevention of pollution, the care of fire, or the protection of wild flowers. Such things as nature trails, guides, or trailside museums are even more remote. Worcester has apparently not begun to use the parks as outdoor school rooms.

Hon. Andrew Haswell Green (1820–1903), sometimes called the "Father of Greater New York" was born on Green Hill, the 500 acre family estate. Mr. Green was Commissioner of Central Park (1858) and was influential in planning the New York Zoological Gardens and the American Museum of Natural History. It was also due to the same foresight that his family farm or old estate was bequeathed to the city of Worcester (about 1905). The Park Commissioners designated to the City Council that its purpose was "to bring to the denizen of the city an epitome of the country: in which walks may be measured by miles and reach sequestered nooks of woodland, or reveal rural landscapes secluded from the discord of human habitation." The author recalls visiting Green Hill Park at one of the meetings of the Federation of New England Natural History Societies at which time the delegates viewed the Green Bird Collection in the old mansion and fed bread crusts to the carp which abounded in Green Hill Pond.

Following the early example set by Andrew H. Green, wild life sanctuaries are coming into their own in Worcester County. The Watatic Mountain Wild Life Reservation (1925), a gift of the Federation of Bird Clubs of New England, consists of 128 acres in Ashburnham. Minn's Wild Life Sanctuary (1927), a gift of Susan Minn of Boston, of 137 acres is on Little Wachusett Mountain in Princeton. The State Fish and Game Hatchery at Wilkinsonville (1892), under the long Superintendency of Arthur Merrill, has done pioneer work in the breeding of grouse, quail, hare, and pheasants. In 1901 it commenced the production of brown, brook, and rainbow trout. Mr. Merrill has also considered the "mess of food fish" for the family man as well as the game fish for the sportsmen. All of these places are worthy of annual pilgrimages for Worcester naturalists.

The Settlement house has made its contribution. Perhaps the most notable is the "Children's Garden City" (1907). Dr. Robert F. Floody, Superintendent of the Worcester Social

Settlement believed that to stop thievery, the thieves themselves must have property. The workers in the garden city have a child mayor, a child police force, water commissioners, etc. To reduce cruelty, animals were furnished as pets. The first year 80 children had gardens. They paid 10 cents, and in return received a plot of land and 5 packages of seed.

If the summary is to be complete we must not omit the newspaper. The Wake Robin Column by Professor W. Elmer Ekblaw appears every Sunday in the *Worcester Telegram*. *Bird Songs about Worcester*, by Harry L. Nelson, who died in 1889, were assembled by friends of Mr. Nelson and published by Little, Brown, and Company (1894). These letters first appeared in Worcester newspapers. Luther Burbank (1849–1926), the world's greatest plant breeder, was born in Lancaster. His early education in horticulture was confined to such newspapers and books as came his way. The story of how this boy—poor in health and poor in wealth—originated the Burbank Potato which later paid his way to California and fame should not only be a classic for Worcester boys, but for all the children of all the nation.

Yes, Worcester and Worcester County is a good place in which to be born a naturalist. Here the boy or girl with a "nature urge" can get a good start. He is assured of sympathetic help and enriching influences. In Worcester the thirty odd nature organizations are the minute men of conservation. To insure the perpetuation of the bobwhite, to prevent the pollution of certain streams and lakes, to befriend the song birds, there are legions of friends. If there is ever need to save the last stand of trees, to wage warfare against the brown tail moth or the gypsy moth, or if the white pine blister rust or elm disease starts to run amuck, or someone offers a bounty on "henhawks"—which means all hawks to many—the friends of nature will rally to the call. The many nature organizations form a powerful influence which is here to stay. Worcester has a great nature heritage—it could be a more careful guardian.

DEFINITION OF NOISE

Most textbooks define noise as a sound without definite pitch produced by an irregular succession of vibrations, but acoustical engineers have just set up a new classification according to the American Standards Association. Noise is now known as "undesirable sound," while a new term "unpitched sound" describes the textbook version of the term.

AN INTRODUCTION TO THE STUDY OF CHEMISTRY*

By LeRoy Reames
High School, Dundee, Michigan

I. Science and Some of its Branches

A. What is the definition of science as given in Webster's *New International Dictionary?* (Definition no. 4)
   1. Would the work of the U. S. Weather Bureau be considered scientific work?
   2. Is agriculture a science?
   3. Name some other divisions of science that you are familiar with.

B. What is the definition of Physics as given in Webster's *New International Dictionary?* (Definition no. 2)
   1. What are the six divisions of Physics?

C. What is the definition of Chemistry as given in your text?
   1. Contrast this definition with the definition as given in the dictionary or some other text.
   2. Compare the definitions of Physics and Chemistry.
   3. Contrast the definitions of Physics and Chemistry.

D. What is the definition of Biology as given in a biology text or the dictionary?
   1. What are the two main divisions of Biology and what fields of study do they embrace?
   2. Chemistry and Physics are often spoken of as "physical sciences" whereas Biology is spoken of as "a science of life." Why?

E. What is Geology? (See the dictionary)
   1. Write a short paragraph on what the study of geology embraces. (See the encyclopedia Americana).

F. What is Astronomy? (See the dictionary)
   1. Write a short paragraph on the field covered in astronomy. (See a standard encyclopedia.)
   2. Contrast the sciences of astronomy and geology.

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* This outline is the author's scheme for introducing chemistry to his class. The pupils wrote out the answers before or during the recitation time. Eleven days were spent in preparing and discussing the unit.

II. Chemistry and its Branches

A. Review the definition of chemistry as given in your text.
   1. What is a chemical change?
   2. How does a chemical change differ from a physical change?
   3. What is meant by the properties of a substance?

B. Look up the word chemistry in a standard encyclopedia.
   1. Write a short paragraph on the origin of the word.
   2. What are the main branches of chemistry proper?
   3. State the scope of each of these main branches.

C. A study of your text.
   1. What is the name of your text?
   2. Who are the authors of your text? What position do they hold?
   3. What company publishes your text?
   4. What is the last copyright date? Is this a new text or a revised edition?
   5. What is the purpose of the preface? Summarize it?
   6. Where is the table of contents? Why is it put in a book of this type?
   7. Where is the introduction found? What is its purpose?
   8. Where is the index? How may it be used?
   9. Where is the appendix? What is its purpose? List the important tables found therein.

D. Write a short paragraph on the scope of the following divisions of chemistry.
   1. Inorganic chemistry.
   2. Organic chemistry.
   3. Physical chemistry.
   4. Colloidal chemistry.
   5. Metallurgy.
   6. Chemical engineering.
   7. Industrial chemistry.
   8. Biochemistry.

E. The ultimate aims of high school chemistry.
   1. State as many legitimate reasons for studying chemistry in high school as you can.
   2. Compare these reasons or aims with those given to you by your instructor.
   3. Be able to state in your own words the aims given to you by your instructor.

III. What Chemistry Has Done for Mankind

A. Luxuries of fifty centuries ago. (See *Stuff* by Beery—pages 7–9)

1. List the foods of fifty centuries ago and the methods of preserving them.
2. What types of stoves did they possess and what were their limitations?
3. Describe the beds in use at that time.
4. Discuss the limitations of their practice of medicine and surgery.
5. Describe the types of amusement available.

B. What the people of fifty centuries ago missed. (See *Stuff* by Beery—page 10)

1. Write a brief paragraph on the things we now enjoy that were not available fifty centuries ago.
2. What do you think may be enjoyed by people one hundred years from now that we do not now possess?

C. List the many things that depend essentially for their production or activity upon chemical changes. (See the *Outline of Science* by Thompson—Vol. III, page 722)

D. Write an article of about 250 words on "How Chemistry Affects Our Daily Life." (See *The Story of Chemistry* by Darrow—Ch. 13)

E. How is chemistry involved in the study of life and life processes? (See *Creative Chemistry* by Slosson—page 3 of the introduction)

IV. Why Normal Men and Women Should Want to Know Something about Chemistry

(See *At Home Among The Atoms* by Kendall—pages 6–11 for the answers to the following questions.)

A. What did Thomas Jefferson say about the importance of chemistry?

B. What did John Adams say about the importance of chemistry?

C. What did William Howard Taft say about chemistry?

D. What was Calvin Coolidge's statement about the work of the chemist?

E. What did Herbert Hoover say about research in pure science?

F. What is the view of the Prince of Wales, now Duke of Windsor, in regard to the value of science and scientific research?

G. Write a short article on "The Importance of Chemistry to the American Citizen" in your own words.

MATHEMATICS IN THE JUNIOR COLLEGE*

By J. S. Georges
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"The new mathematics is a sort of supplement to language, affording a means of thought about form and quantity and a means of expression more exact, compact, and ready than ordinary language. The great body of physical science, a great deal of the essential facts of financial science, and endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematical analysis, and the time may not be very remote when it will be understood that for complete initiation as an efficient citizen of one of the new great complex world-wide states that are now developing, it is as necessary to be able to compute, to think in averages and maxima and minima, as it is now to be able to read and to write."

This quotation is taken not from the writings of a mathematician, nor from the lectures of a teacher of mathematics. It represents the evaluation of the functions of mathematics in the scheme of general education by a layman. It is the opinion of H. G. Wells expressed in "Mankind in the Making."

If this be the rôle of mathematics in the training of the individual so that the great body of physical science, and the essential facts of financial science, and the social and political problems be made accessible to him, then surely it must occupy a place of prominence in the scheme of general education. But what is the true picture?

On every hand men prominent in educational circles, leaders into whose cares are entrusted the training of the youth of the land, express their beliefs that mathematics is not needed as an integral part of the educative process. In the new education, many courses form the framework of the educational structure, but mathematics without which the great body of physical science, the essential facts of financial science, and the endless

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social and political problems are neither accessible nor thinkable is pushed aside, stamped "one of the electives."

Several factors, doubtless, have contributed to the conviction professed by many of our leaders that general education is to be acquired not with the aid of mathematics, but in spite of it. In the first place, we find universal lack of understanding of the true nature of mathematics. We the teachers of mathematics, and the devotees of the subject are in a large measure responsible for such an attitude toward mathematics. To the average educator and layman, mathematics means arithmetic, algebra, geometry, etc. When mathematics is being attacked, the attack is directed against arithmetic, or algebra, or geometry, either singly or jointly. In the traditional organization, and presentation of these branches of mathematics, not only do we lose sight of the unique functions of mathematics as a language affording a means of thought about form and quantity as no other language does, but actually replace the development of mathematical thought by manipulative skills. The acquisition of genuine understanding of the fundamental concepts of mathematics is made incidental to the acquisition of skills and abilities to perform a large number of operations that are necessary only in the training of the specialist in the subject. The appreciation of the idea that the concepts of mathematics are in most cases abstraction of our perceptual experiences does not constitute an instructional aim of our arithmetic, algebra, or geometry classes. In the learning of the many processes and operations presented in our traditional courses in algebra or geometry, the student is often not given an opportunity to recognize the mathematical concepts as prototypes of similar activities in other intellectual endeavors. Do we stress mathematics as a unique method of thinking? Does the student of algebra or geometry, or even calculus realize and appreciate the fact that the history of mathematics is a history of man's struggle to understand the world and the universe of which he is a part?

No wonder that today the layman lacks an understanding of the true nature and functions of mathematics! Yesterday, he was a student in our classes, and we failed to present mathematics to him as a method of thinking; the highest and the most excellent achievement of the race in the conceptual world for the handling of ideas escaped him entirely, and he was not even aware of its existence. The instrument created by man for the transcending of sensations, for the apprehension of abstractions,

and for the idealization of intelligence was traded for manipulations soon forgotten and never used. That there is a universal language, precise, concise, and efficacious in the study of order and anomaly, harmony and incompatibility, symmetry and distortion, correspondence and dissimilarity, instability and invariance, in the quantitative world of form, and in the general domain of thought, was hidden from him, and he left the mathematics classes without ever having instilled in him a desire for its understanding and a want for its use. And today that ideal instrumentality for the recognition, observation, determination, expression, and generalization of relationships in natural phenomena which should be the equipment of every educated man and woman lies hidden to them. Is it any wonder that not understanding what mathematics really is, they are neither sympathetic toward its maintenance nor anxious to have their children grasp at shadows.

The attribute which we might call "mathematical pathology," is exhibited and exemplified in every phase of life, and more intensely by those who denounce mathematics more loudly. To an impartial analyst of our present economic order the lack of quantitative thinking must be more than apparent. The essential facts of economic science are only thinkable to those who have had a sound training in mathematical analysis, yet we expect miracles to happen! Our present economic disorder is but a mute testimony to the immutability of this law. This priceless heritage to the possession of which every thoughtful person is rightfully entitled, has been exchanged for a mess of useless tricks. We the teachers of mathematics, being the guardians and the custodians of this valuable inheritance have been unfaithful to our trust, and have failed to carry out our sacred commission. Once this truth is recognized by the thoughtful person, he must feel resentful, and rightly so, toward every teacher of mathematics in the high school and college for neglecting to interpret mathematics to him so that the essential facts and laws of the economic and social order might have been accessible to him.

The lack of quantitative thinking is manifest in our daily lives. The average individual is not in the possession of even the elementary financial, economic, or social laws which govern his daily life. Wells is right in claiming that this understanding is feasible only for the individual who has had a sound training in mathematics as a method of thinking; he is not to be blamed.

He has been deprived of a method of thinking essential to the understanding of the laws that govern his life, which rightfully belonged to him. Instead of inspiring his soul and stimulating his spirit with the manifestations of mathematics in life, he was faithfully drilled to acquire the art of "hunting the unknown," and in the drudgery of solving myriads of meaningless and puzzling problems. Certainly, such must be the reactions of any intellectual person who becomes cognizant of the true mission of mathematics too late.

Nowhere else is this lack of quantitative thinking manifested as in the presentation of the findings and results of the so-called experts and investigators. Study carefully the statistical reports clothed in the language of science, basing their validity upon numbers, for numbers cannot lie; numbers obtained by combinatory laws of mathematics into means, modes, medians, coefficients of variation and correlation, indices, and trends. Vehement in their denunciation of the educational values of mathematics yet borrowing mathematical terminology in presenting their findings as examples of valid and sound reasoning.

Not very long ago, much money was spent in one of our leading universities, to investigate the problem of determining the functions of the educative process on the basis of activities. Much time was spent in the analysis of many types of activities. With keen interest the results of the investigation were anticipated, for they were to enable us in the various subjects to determine, modify, and clarify our aims, functions, and objectives on the basis of their recommendations. In what form do you think that valuable information was presented to be a guide in our investigation of the problem relating to the teaching of our own subjects? Hundreds of items were listed, one after another in endless succession. Whether there were significant relationships between them or not, certainly was not apparent to the reader, for not even a comprehensive classification was given. What the interrelationship of each listed item was to the whole group or to other items, was left to the individual interpretation of the reader. The whole enterprise was but a poorly presented first step in the scientific method, namely the assembling of data. Yet such investigators are among the most hostile adversaries of mathematics. Truly, as Sir Oliver Lodge exclaims, "the mathematical ignorance of the average educated person is appalling."

Still another factor contributing to the acrimonious discus-

sions concerning the values of mathematics as an educational subject by those least equipped to analyze and discuss the merits of mathematics is the failure to distinguish between mathematics and mathematicians. Without hesitating to recommend large doses of social studies to all as a "cure-all" for our social evils, whether the individual has the inherent capacity to benefit by such treatment or not, they are convinced that not all are capable to react favorably to a similar treatment in mathematics. Analyze the courses of study of our junior colleges throughout the country, determine what courses are required and what are elective, and you shall be surprised, perhaps, that in most of them not even one semester of mathematics is required. Yet we are told, and feel that truth is spoken to us, that "the endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematical analysis."

If by mathematics is understood the art of calculation, the skill in algebraic manipulation, the mechanical processes of the calculus, perhaps we must grant that not everyone can acquire these skills to a high degree of efficiency and consequently cannot benefit by that type of instruction.

That such is the case, we need only examine the records of the average teacher of algebra or of geometry and note the high per cent of mortality. But as one great mathematician put it, "mathematics is the science of how not to compute." We reiterate that computation and manipulation are not genuine mathematics. That mathematics is a method of thinking; that instead of mathematics being unreal, it is imbued with the very essence of reality. Properly presented, as Whitehead has well said, "Algebra is the intellectual instrument which has been created for rendering clear the quantitative aspects of the world. . . . To talk sense is to talk in quantities. . . . You cannot evade quantity. You may fly to poetry and to music, and quantity and number will face you in your rhythms and in your octaves. Elegant intellects which despise the theory of quantity are but half developed. They are more to be pitied than blamed."

As a method of thinking, mathematics can be of great service to him who is called upon to think. He can use this method of thinking in dealing with quantity and quantitative relationships without being a mathematician. It is important for us to accede to this fact, that mathematics is a method of thinking

to be used by the individual in understanding the quantitative world about him without paying the sacrifice of becoming an expert mathematician. True, the muse of mathematics reveals the majesty of the shrine only to the initiated, but the uninitiated are not barred from the benevolence of its truths.

Consider for example only one of the many pillar concepts of mathematics, the concept of function. This concept can be presented in such a manner that will render homogeneity to a course in algebra, and will eliminate the prevalent heterogeneity of topics though inherently related yet without explicitly stated associations and relationships between them. Functional thinking, once having been acquired by the individual, can be used constantly by him in his dealing with quantities between which relationships are sought. Functionality can be so presented that the student will see it as having its root in the common propensity and power of human beings to associate one thing or idea with another thing or idea. Functional thinking embodies the following characteristics which must constitute a basis for the establishment of correct habits of thinking in general, namely: the recognition of dependence and the consciousness of the existence of functional relationship between quantities and ideas; the utilization of the quantitative or scientific method of procedure in the determination of data for the recognition and understanding of the nature of the relationship between the factors of a phenomenon; and finally, the symbolic representation of the results of observation, mensuration, and experimentation, and the statement of the discovered relationship in terms of mathematical symbols as precise, general laws. Functionality is inherently present in the process of measurement, the degree of accuracy, approximations, the transformation of units, the comparison of magnitudes, the variation of the size and shape of a geometric figure, in similarity and congruence. It is manifested in the study of variation, correspondence, tabulation, graphs, evaluation, transformations, invariance, and limits. Algebraic and transcendental functions are but concrete reflections of this dominant idea. Transformations are the logic of functionality in seeking to establish the laws of variation. Yes, the concept of function can be so presented that it will become one of the supreme aims of mathematical instruction, to make the process of quantitative thinking accessible to the individual in order that he may use it effectively in all the problems of life.

Whether or not the teachers of mathematics in the junior college are willing to admit that there exists a problem, a genuine problem relating to the teaching of mathematics, the problem nevertheless exists and is a real problem. In the analysis of this problem we are forced to distinguish between two types of education: the specialized training required by those who are to major in mathematics, pure or applied; and general education whose objective is the development of the individual into a well-rounded citizen, capable of adjusting his life to the society. For the specialized instruction of the future mathematician or the engineer our traditional courses might well be left alone. Algebra, trigonometry, analytics, and the calculus equip him with the necessary knowledge and the prerequisite skills to continue his specialization in the subject. But the relations of these courses to general education need further study and analysis.

We state the problem in the following terms: What mathematics ought a college student in general education have?

In the statement of the problem we call attention to the word *ought*. Only too often the problem is misrepresented and misstated. It is stated in the form: What mathematics the average man does not have. We have called attention to the fact that the average educated person is lacking in mathematical knowledge. Not being in possesion of such knowledge, how can we expect him to use it? Is it not fallacious to set up a problem for investigation, the solution of which is assumed a priori, then proceed to substantiate that assumption? Yet, that is one of the most vital factors that has affected mathematical requirements in both the high school and college. As a result of inadequate and one-sided analyses of the values of mathematics in specified activities by educational investigators, the conclusion is reached by school authorities in general that little or no mathematics is needed.

In a recent study which was supposed to disclose scientifically the nature and the amount of mathematics needed in Freshman chemistry, the findings are summarized thus by a noted educator: "The mathematical information needed in Freshman chemistry is limited to arithmetic and simple algebraic processes with a wide range of denominate numbers." Tables of frequencies are then given for denominate numbers, arithmetical fractions, algebraic addition, equations of the first degree in one and in two unknowns. Nothing is said, however, of symbolic

representation, of exponential representation, of variation and dependence, of algebraically stated and graphically presented functional relationships, of the rate of change and the range of variation, of transformations, of mathematical laws of direct, inverse, and exponential variation. How many cases were present? None were given, for obviously none were seen by the investigator.

Thus, first there is a general misconception of our problem. Then experts in other fields, who deny the existence of a solution to the problem, proceed systematically and "scientifically" to solve the problem; always knowing beforehand what they intend to find, then after finding it, exclaim that much to their surprise they find that little or no mathematics is needed in the special activity analyzed. Then they proceed to generalize that little or no mathematics is needed in all fields of endeavor, with the exception of mathematics itself.

May we humbly remind such scientific investigators that by their own statements they prove that there is a great need for the subject that they denounce. The generalizations which they make from insufficient data proves conclusively that there is a great need for mathematical instruction.

Moreover, the failure of experts to understand the phenomena in their own fields prompts us to wonder if mathematical thinking is not needed there in quite sufficient amounts. Such failure to understand important problems which affect our lives, and illogical and unscientific solutions imposed upon us which are shortly discarded and replaced by other illogical and unscientific solutions, prove conclusively that there is much need for the application of mathematical thinking in their own fields. Why are we not justified in surmising that: Had the experts in this field had a sound training in mathematical analysis, the disastrous results in our economic structure might have been avoided? And until that training is acquired and used, we may surmise further that we shall continue to be affected by such failures from time to time, periodically, but in greater intensity.

It is thus clear that we cannot determine what mathematics an average educated person ought to have, from considerations which are based entirely on negation. To assume a priori that no mathematics is needed in any given activity then analyze that activity to justify the assumption does not answer the question. It might be possible that no mathematical ideas can be used in such an activity. It might equally be possible that

mathematical ideas can be used, but were not used because the person engaged in that activity did not have them. What that person might have done if he did have an adequate mathematical training, still remains to be answered. Clearly we cannot answer the question, neither can the person who analyzes that activity. We can, however, by analogy deduce an observation. We do know that the success of a research worker in his own specialized field depends, to a great extent, upon his ability to use the scientific method. And the scientific method is but functional thinking put into practice. For as Poincaré has well said: "It is not things themselves that science can reach, as the naïve dogmatists think, but only the relations of things."

What is true of scientific work is equally true of any quantitative undertaking. Mathematical thinking is needed in the recognition of dependence and variation; in the identification of variable and constant factors; in the formulation of the problem; in the assembling of data; in the study and analysis of data; in the understanding of the relationship; and in the applications of the solution of the problem. Serious thinking is done in any field by those who are qualified to use mathematical thinking. In many instances, the difference between excellent and mediocre work is a matter of the mathematical background.

If we claim that mathematics is more than a collection of technical abilities and manipulations of specific processes, if it is a method of thinking, if it is closely associated with the common faculties of man as a standard of excellence for each of them, then surely mathematical concepts ought to be made accessible to the college student who is called upon to use the thought processes constantly. But how shall we determine specifically just what mathematical concepts should be made accessible to him?

In endeavoring to determine what mathematics a student of general education ought to have, we must distinguish between two types of students. In the first type we identify the student of average intelligence and worthy educational purposes, who enrolls in the courses of the various departments to learn something about the nature of these branches of knowledge, and their unique contributions to the progress as well as the maintenance of our present day civilization. The education of this type of student may terminate with the junior college, or he may continue his studies in the senior college.

The second type is equally intelligent and is endowed with

serious educational purposes, but with the ultimate end in mind. He takes the required courses in the various departments as integral part of his general education, but his program leads toward specialization, and focuses his attention and studies to the work of some particular field in order that he may specialize in it later.

With this definite task in mind we might formulate a method of procedure to determine the necessary data for the solution of our problem. The student in our junior colleges is called upon to use thought process in the various courses he studies. If he ought to have certain mathematical ideas and concepts for a better understanding of the ideas and concepts in the various courses, then an analysis of such courses should disclose to us where and how mathematical thinking might be used to advantage. In the conduct of such an analysis, we must of necessity, make certain reservations.

First, the intellectual activities in the various courses should be analyzed by a mathematically trained investigator. The investigator who is trained to use mathematical thinking himself is able to see occasions where such thinking might be used to advantage by others. The investigator, however, need not be an expert mathematician.

Second, the intellectual activities to be analyzed should include all which the student engages in, or will engage in.

Third, the activities should be analyzed by the investigator himself, impartially and scientifically, and not depend upon the opinions of the teachers of the various courses. For as pointed out previously, many experts in non-mathematical fields are not sympathetic toward mathematics, and lack the necessary training in mathematical thinking to see its many possibilities.

Such a method was used by the writer at the University of Chicago and reported in the January, 1932, issue of the SCHOOL SCIENCE AND MATHEMATICS. As reported there the method consisted in: (1) conferences with instructors of junior college courses in the various departments; and (2) analysis of the textbooks and lectures. As a result of the conferences with the members of the various departments, the field of investigation was limited to these courses: (1) Biological sciences, 3 courses; (2) Chemistry, 2 courses; (3) Economics, 3 courses; (4) Geography, 2 courses; (5) Geology, 3 courses; (6) Physics, 5 courses; (7) Psychology, 3 courses; and (8) Sociology, 2 courses.

Each topic or sub-topic was carefully studied and analyzed,

keeping in mind the important question: "What mathematical concepts, principles, and processes have been used in the presentation and development of the topic, and further, what mathematical concepts, principles, or processes might have been used to advantage by the writer of the textbook?" The mathematical information secured from the analysis of each topic was recorded on separate cards. In all, there were 3,765 cards filed away for further analysis.

In the next stage of the analysis, the cards were classified according to the fundamental mathematical principles with which they dealt. The cards belonging to the same class were put in a folder and labeled.

The 3,765 cards were reduced to 62 folders each dealing with a fundamental mathematical concept, or process. Finally the folders were grouped under more comprehensive concepts. Their enumeration follows:

1. Number: real and complex; scalar and vector; approximation; finitude and infinity.
2. Representation: tabular and graphic; algebraic or symbolic; geometric or vector; index, and proportional.
3. Functionality; statistical; dependence and variation; comparisons, differences and ratios; correlations and regressions; algebraic functions, linear, quadratic, cubic; transcendental functions, circular, and exponential; variables, parameters, and constants; subscripts and superscripts; rate of change; range of variables; maxima and minima; velocity and acceleration; continuity; periodicity; and limits.
4. Geometric principles: elements and forms; mensuration; relationships; projection; and symmetry.
5. Transformations: Substitutions; evaluations; equations.
6. Groups: infinite and finite; abelian and non-abelian.
7. Invariance: similarity; equivalence.
8. Class: correspondence; finite and infinite; denumerable; and continua.
9. Probability: combinations; normal binomial distribution; errors; and approximations.
10. Series: sequences; convergence and divergence; limit; and infinity.
11. Logic: doctrinal and prepositional functions; postulations; demonstration; analysis; induction; and eduction.
12. Generalizations: special cases; laws.

That these findings are but a restatement and reiteration of the fundamental, basic and pillar concepts of mathematics needs no comment. They are the obvious manifestations of mathematical thinking in the life and the world, for the materials of mathematics have their roots in the world of experience and sensation, and they become mathematical when they are no longer limited to that world, but transcend it and

become ideal conceptual creations. And it is in that rôle that they are to serve the educated man and woman who is not a mathematician. Though derived from experience and activities of life, they are to be felt and seen as standards of excellence for those experiences and activities.

The knowledge of the ultimate association of mathematical concepts with the activities and functions in non-mathematical fields is by no means well established. Many a psychologist, for example, who is daily engaged in the study of sensations, stimuli, and reactions, has never heard of the idea of groups in mathematics, or that the group concept has any direct bearing on the field of sensations, or that it might contribute in any manner to a better understanding of their nature. It is often pathologically brought to our attention that those who are engaged in developing in the minds of their students the love for, and appreciation of the moral and ethical ideas and ideals, and a consciousness and abiding faith of their authority in the conduct of life are ignorant of the beautiful doctrine of limits which could illuminate the whole process of idealization, and interpret its true nature. Living in a world of constant change of social customs and ethics, and subjected to the endless phenomena of changes and transformations, the educated man is not aware of the mathematical concept of transformations which is but a refinement of his own powers of association of ideas. The universal interest in the things that abide, in immutability transcending time and change, in immortality, in commemoration of the unperishable in virtue, in beauty, the spirit of the eternal and everlasting, the quest for abiding reality, for eternal verities, so beautifully expressed in the mathematical concept of invariance is seldom a learning product of our schools.

The mathematical ignorance of the educated man, for which he is hardly to blame, has resulted in a very serious problem in the education of the specialist. In many courses mathematical concepts and processes are not utilized and are avoided if possible. Examine carefully the solutions of problems presented in any college chemistry text and you will appreciate the significance of this statement. But economically or not, and justifiable or not, mathematical processes are avoided through ignorance. In his elementary courses, say in sociology and anthropology, the future sociologist does not come in contact with mathematics and hence sees no necessity for taking more courses in mathematics than are required for graduation. His specializa-

tion continues and he finds himself in a few years seriously engaged in research, but he also finds, to his utter dismay and discouragement, that he needs the services of mathematics of the highest type. He did not study the calculus in the junior college; it was felt that he did not need it; now in the graduate school he needs the services of the calculus of variations. College algebra was avoided as if it were a plague, now he finds that he must have the ability and understanding to handle differential equations, definite integrals, elliptic functions, and the theory of probability. Between his junior college instruction and his graduate work, through no fault of his, a gap has been created that he is not able to bridge over. Who will make the mathematical concepts accessible to him? Not the sociologist who is directing his research, for he himself is in no better circumstances. Not the mathematician across the campus for he is not interested in the problems of sociology and anthropology. So the problem stands, and faces us as an evidence of our utter failure to coordinate instruction, especially when relating to specialization.

A number of universities and junior colleges have undertaken the solution of this problem, and have organized courses in mathematical analysis. We at the Wright Junior College have been carrying on an experiment for the past three years to determine the units of instructions in Freshman mathematics.

The City Junior Colleges of Chicago were organized to provide for the high school graduates of the city a general education. In this "new deal" in education certain courses are made required. These courses constitute survey courses in physical sciences, biological sciences, social sciences, English, and humanities. Special courses are offered as electives. Many of these electives are required for preprofessional courses, such as premedical, pre-engineering, etc.

The status of mathematics in this organization is that of an elective course. It is true that pre-medics are required to take one semester, and pre-engineering, two semesters, and four if possible. However, the student of general education is not required to take any mathematics, but may elect it if time permits, and if he feels so inclined.

Consequently the department of mathematics at the Wright Junior College offers the following courses of instruction.

1. A Survey Course in Mathematics, one semester; 3 lectures and one quiz a week; credit, 3 hours.

2. Mathematical Analysis, two semesters; 3 lectures and 2 quizzes a week; credit, 5 hours.
3. The Calculus, two semesters. This is a traditional course.

The Survey Course in Mathematics is planned for students who have had one year of high school algebra, and one year of geometry. Students not having these prerequisites also are permitted to take the course by the permission of the departmental head.

The course is divided into three main parts, each considering a special aspect of mathematics.

Part I. Introduction to the Science of Mathematics.
- Unit 1. Elements of Mathematics.
- Unit 2. Simple geometric forms.
- Unit 3. Algebraic principles applied to geometry.
- Unit 4. Higher geometric forms.
- Unit 5. Mathematical reasoning.

Part II. Application of Mathematics to Exact Sciences.
- Unit 6. Functional relationships.
- Unit 7. Linear function.
- Unit 8. The power function.
- Unit 9. The quadratic function.
- Unit 10. The exponential function.
- Unit 11. Trigonometric functions.

Part III. Application of Mathematics to Social Sciences.
- Unit 12. Classification of data.
- Unit 13. Presentation of data.
- Unit 14. Analysis of data.
- Unit 15. Relationships between data.
- Unit 16. Probability.

The course in Mathematical analysis is planned for students who have had one and one-half years of high school algebra. It presents the materials traditionally taught as college algebra, trigonometry, and analytic geometry. However, it treats these subjects as phases of mathematical analysis together with the elements of the differential and integral calculus.

The course is divided into the following units:
- Unit 1. Functional representation.
- Unit 2. The linear function $f(x, y) = 0$.
- Unit 3. The linear function $f(x, y, z) = 0$.
- Unit 4. The power function $y = ax^n$.
- Unit 5. The quadratic function $y = ax^2 + bx + c$.
- Unit 6. The polynomial function.
- Unit 7. Trigonometric functions.
- Unit 8. The quadratic function $f(x, y) = 0$.
- Unit 9. Trigonometric analysis.
- Unit 10. Exponential functions.
- Unit 11. Polar representation.
- Unit 12. Parametric representation.
- Unit 13. Quadric surfaces.

The following objectives of the Survey Course in Mathematics are indicative of the emphasis placed upon mathematical thinking.

1. Recognitions
   a. That mathematics is a science with its own *elements, assumptions, processes,* and *laws.*
   b. That the concepts of mathematics in most cases are abstractions of perceptual experiences.
   c. That the concepts and processes of mathematics were developed by mankind gradually.
   d. That many races and civilizations have contributed to the final development of mathematical concepts.
   e. That mathematical concepts and processes are prototypes of similar activities in other intellectual endeavors.
   f. That mathematics is a unique method of thinking.
   g. That an understanding of physical phenomena, and many of the social and economic problems presupposes an adequate mathematical background.
   h. That the history of mathematics is a history of man's struggle to understand the world and the universe of which he is a part.

2. Understandings
   a. The meaning of number, and its specific aid in the development of civilization.
   b. The meaning of geometric form, and its significance in the industry and art.
   c. The meaning of function, and its use in the study of phenomena.
   d. The meaning of symbolic representation, without which generalizations are impossible.
   e. The types of reasonings used in the discovery and the proof of a law.
   f. The processes of mathematics which are used as efficient tools in the statement and solution of practical problems.
   g. The interrelations between the various branches of mathematical thought, as manifestations of the same general truth.

3. Abilities. The development of ability to
   a. Use the six fundamental operations accurately and with facility, including logarithmic computation.
   b. Use the graphic method in the study of relationships.
   c. Apply the various types of functions to the study of specific relationships.
   d. Solve algebraic equations.
   e. Use statistical methods and processes.

WORLD CHEMICAL ACTIVITY

Here are the highlights of world chemical activity as summarized by T. W. Delahanty, of the Commerce Department's Chemical Division:

Germany has a seasickness remedy and an improved diphtheria vaccine.

Japan has developed a smallpox vaccine and a sleeping sickness serum.

India has produced a snake venom treatment for cholera.

Czechoslovakia is extracting narcotics from empty poppy heads.

England has built the first factory for the manufacture of synthetic vitamins on a large scale.

THE TEACHING OF HEAT TRANSFER PROCESSES THROUGH THE USE OF A WATER TRANSFER ANALOGY

By Temple Chapman Patton
Worcester Academy, Worcester, Mass.

INTRODUCTION

It is generally conceded among teachers that the average student learns new facts and grasps abstract conceptions more readily if they are presented to him in terms of his past experiences. With this in mind, the following analogy is submitted as an aid to the student in his understanding of the processes whereby heat is transferred.

The purpose of this analogy is to establish a correspondence between the three recognized methods of heat transfer, i.e., conduction, convection, and radiation and three corresponding methods of water transfer. The first method of water transfer to be described will be termed a multiple pass method and will correspond to heat transfer by conduction. The second method of water transfer to be outlined will be called a circulation method and will correspond to heat transfer by convection processes. The third method of water transfer will be termed a spray method and will correspond to heat transfer by radiation.

Following this outline of the three water transfer processes, there will be discussed in detail the similarities existing between these three water transfer methods and the three recognized methods of heat transfer.

THREE SYSTEMS OF WATER TRANSFER

Suppose it is desired to transfer a large quantity of water from a source of water supply such as a pond to a large open water tank situated several hundred feet distant. Conceivably, this might be accomplished in three ways.

1. MULTIPLE PASS SYSTEM

(See Figure 1)

With the aid of several thousand men lined up in parallel rows stretching from the pond to the tank, the water could be passed in pails from one man to the next.[1] Each man would stay

[1] The water could also be transferred by pouring the water from one pail into the next.

put at his position in the row and his only job would consist in taking pails of water from the man next to him on the pond side and giving them to the man next to him on the tank side. In this way pails of water would be continuously moved from

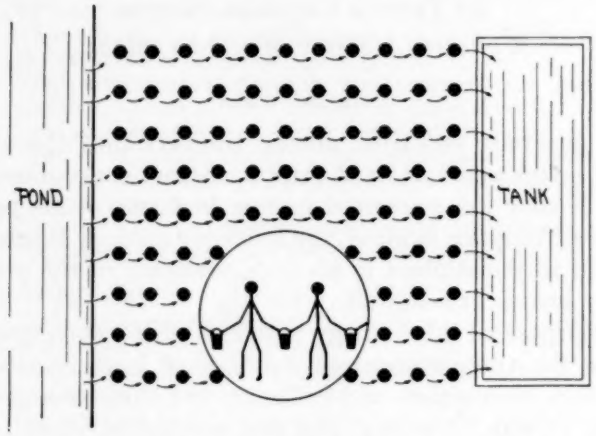

FIG. 1. Multiple Pass (Conduction) System of Transfer.

the pond to be eventually dumped into the open tank by the end man of each row. Note that the lines of men remain rooted to their set positions. Only the water experiences a constant forward motion. This method of water transfer will be called a multiple pass system.

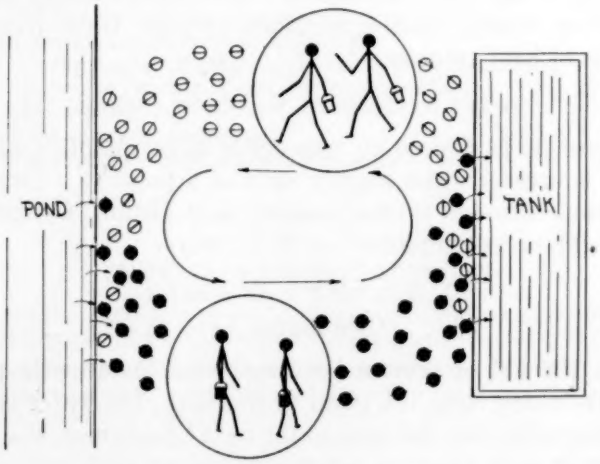

FIG. 2. Circulation (Convection) System of Transfer.

2. CIRCULATION SYSTEM

(See Figure 2)

Using this same group of men, another system for the transfer of the water might possibly be organized. With this arrangement, each man is supplied with an individual pail. He fills it at the pond, takes it personally to the tank, empties it, and returns for a refill. Because of the large number of men employed and to avoid confusion, two broad paths are marked off, one for those coming from the pond with full pails, one for those returning to the pond with empty pails. Again there is a gradual movement of pails full of water towards the tank but with this system both men and pails take part in the circulatory motion and the mass movement takes place along wide paths. This method will be called a circulation system of water transfer.

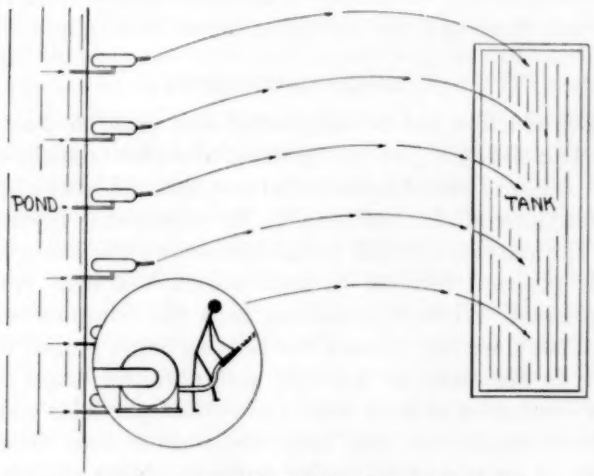

FIG. 3. Spray (Radiation) System of Transfer.

3. SPRAY SYSTEM

(See Figure 3)

Finally, a smaller group of men could be supplied with powerful pumps capable of delivering forceful streams of water. Several men would be assigned to each piece of pump equipment, these pumps to be spaced equidistantly along the edge of the pond. With this method a barrage of high velocity water could be sprayed across the space intervening between the pond and the open tank. Again, a steady forward motion of water

occurs, but with this arrangement, no intermediate agency is required to get the water over. The men remain stationed at their posts along the edge of the pond. The water is forcefully projected across the space by imparting to it an initial high rate of speed. This method will be called a spray system of water transfer.

As was mentioned at the beginning of the article, these three methods of water transfer have their close counterparts in the transfer of heat. With heat transference the multiple pass method is called CONDUCTION, the circulatory method is called CONVECTION, and the spray method is called RADIATION.

With heat transference, not water, but heat is the quantity which is being transferred; not men, but the small particles of matter which compose the material are acting as the agency whereby the heat is transferred. The analogy is incomplete in certain respects. In general, however, the correspondence is excellent.

HEAT CONDUCTION

Heat *conduction* can be considered as a *multiple pass* system of heat transference (see first method of water transfer outlined above). A bar of metal is heated at one end and heat conduction to all portions of the bar results. No observable motion takes place. The particles of the metal composing the bar remain set in their position relative to each other. Yet heat transfer is accomplished. Without inquiring into the complex nature of heat transfer, we can picture the heat as being passed from one particle to the next as was the water in the water analogy. A good conductor of heat would consist of particles which were capable of rapidly passing large amounts of heat from hotter portions of an object to cooler portions. Most metals are excellent heat conductors. Such rapid conduction or transfer in the water analogy would correspond to a husky and active group of men speedily handling large pailfuls of water. A heat insulating material, conversely, such as cork, would be comprised of particles which were reluctant or sluggish or passive in their ability to transfer heat from hotter to cooler portions of an object. Such a condition of slow transfer in the water analogy would correspond to multiple passing by a group of puny and ineffective men, too weak to handle but spoonfuls of water at a time, and even then in an idle and slow manner. All intervening cases of fair insulators, poor conductors, etc., would

have corresponding similarities in the water analogy by assuming the groups of men to have corresponding characteristics.

It is possible to carry the analogy further to picture other phases of heat conduction.

For example, finely divided materials when loosely packed exhibit excellent insulating properties, even though the material in a dense compact state is a good heat conductor. Thus glass, although a fairly good conductor when in the form of sheet glass, becomes an excellent insulator when drawn out into the form of fine fibres to give a material closely resembling cotton batting in appearance. This increase of insulation power with greater degree of subdivision and looseness of pack is quite general. It is probably due to three reasons. (1) Infiltration of air into the voids of the material introduces an excellent insulator (air) into the makeup of the material and consequently drastically modifies the properties of the resulting structure. For example, in the case of "glass cotton," the material is in reality an air-glass mix and hence combines the heat conduction characteristics of both the glass and the air. (2) Contact between adjacent solid particles is poor. Only point or edge contacts are made, due to the looseness of the structure. Hence the paths for heat conduction from solid particle to solid particle are constricted and choked at numberless points. Such contractions effectively cut down the quantity of heat which is conducted from solid particle to solid particle. (3) Furthermore, direct paths for heat flow through the solid material are lacking. Heat flowing from a hot temperature source to a cooler zone will be obliged to take an irregular or zig-zag course through the loosely packed material. This has the same effect as increasing the thickness of insulation and hence results in a decrease in the quantity of heat transferred.

It is to be noted here that there are definite limitations to the extent to which the looseness of pack can be carried. As the material becomes less dense, heat transfer by the two other processes of convection and radiation begin to contribute to the total heat transferred. Probably only by experiment can those conditions be determined in which optimum insulation characteristics result for any given type of loosely packed material. (Such materials as mineral wool, slag wool, dry sawdust, fibre board, dry seaweed, and straw are other examples of this type of loose or porous insulation.)

In the water analogy, the conditions corresponding to the

above can be depicted by assuming two groups of men, one group husky and active (solid particles) thoroughly mixed and intermingled at random among the second group of men weak and inactive (air particles). Furthermore, to complete the picture, it may be supposed that their distances of separation are relatively great corresponding to looseness of pack. Then, as with the heat transference, the quantity of water transferred from the pond to the tank would be enormously reduced for three reasons. (1) Because of the intermixture of the strong and active with the weak and inactive, only spoonfuls of water would be passed along many of the paths leading to the tank. This would effectively cut down the total quantity of water transferred almost in direct proportion to the percentage of the weak and inactive men group present. (2) Because of the large distances of separation between the men, even the strong and active group would be slowed up, would be forced to handle smaller sized pails. (3) Because of the heterogeneity of the group, the heavy pails would be forced to travel along zig-zag courses in their irregular and indirect movement towards the tank. This would have the same effect as increasing the distance between pond and tank and would result in diminishing the quantity of water transferred.

Finally, materials in general become better heat conductors with increase of temperature. This might be explained, using the water analogy, by pointing out that at low temperatures the men are cold or partly frozen, their muscles are stiffened and the rate of water transfer is cut down. With higher temperatures, they thaw out and their muscles loosen up, they become more active and the water transfer is accelerated.

HEAT CONVECTION

Heat *convection* may be considered as a *circulation* method of heat transfer (see second method of water transfer outlined above). The correspondence with the water analogy in this case is excellent. No multiple passing takes place. Each particle takes on an increased increment of heat at the higher temperature source and then proceeds with it personally to the lower temperature receiver to deposit it. To facilitate this circulation of thousands of particles so that those hot particles coming from the heat source avoid bumping or conflicting with those cooler particles returning to the heat source, large avenues of travel are established or adopted for the mass movements. In

certain cases, roads of travel are forced upon the particles, as in the case of forced convection currents. Many of our newer type air-conditioned houses have hot-air systems in which conditioned air particles are forcefully circulated to all parts of the house and returned by a blower system actuated by electrical power. In other cases, the particles gravitate along certain paths depending on their condition (density) and the characteristics of the surroundings in which they find themselves. Hot water heating systems depend on this type of natural circulation. Climatic conditions are largely dependent on the huge mass movements of air over the surface of the earth. Such large scale natural convection currents are responsible for wind storms, heat waves, hurricanes, cold spells, etc.

Since this system of transfer requires particles which are free to move or circulate we find in general that only gases or liquids make use of this method of heat transfer. If by any chance the liquids or gases are blocked in their circulatory motion, they will have to resort to the multiple pass (conduction) method or the spray (radiation) method for heat transfer. With convection, the heat transferred will be in direct proportion to the number of particles participating in the circulation, their average velocity, and their capacity for taking on heat. Referring to the water analogy, it can be pointed out that in a similar manner the water transference to the tank from the pond will be in direct proportion to the number of men participating in the circulation, their average velocity, and the size of the water load which they can carry.

HEAT RADIATION

Heat *radiation* may be considered as a *spray* method of heat transfer (see third method of water transfer outlined above). As with the case of water transfer by the spray method, it is characterized by the rapidity with which the heat is transferred once it has been hurled from the heat source. With heat transfer the heat is projected at the enormous velocity of 186,000 miles per second through free space. Our best example of this type of heat transfer is illustrated by the sun's radiation to the earth, a method of pure radiation transfer. Note that no intermediate agency is required for the transfer, that the effect is completely a surface to surface phenomenon. This might correspond with the water transference to a situation in which a bottomless ravine separated the pond from the open tank.

Liquids or solids interposed between a high temperature radiating source and a cold receiving surface act to hinder or completely prevent the transfer of heat. In the case of such partial or complete blocking, the interposed material receives and is heated by the high velocity radiation. Solids, when opaque, are almost perfect blockers of heat. Liquids also effectively absorb heat radiation. Gases have little effect on cutting down radiation and then only when the distance of the travel of the radiation through them is great.

Reasoning from the water analogy, this situation could be explained as corresponding to the erection of a solid wall or to the establishment of a curtain of liquid to interfere with the streams of water projected from the pumps to the tank.

Finally, heat radiation is proportional to the type of surface emitting the heat radiation, to the area of the emitting surface, and to the fourth power of the absolute temperature of the heat source.

Referring to the water analogy, the amount of water sprayed across to the tank can be pictured as varying according to the capacity of the pumps being used. Carrying the picture over into heat transfer pumps of small size might be compared with bright, smooth metal surfaces, pumps of large size compared with irregular, dull, non-metallic surfaces. Pumps of intermediate capacity would correspond to intermediate types of surfaces.

The water sprayed across would also be proportional to the number of pumps in action. Increase of shore frontage or extent of shore line would allow more pumps to be brought into action, would result in a greater total rate of water transfer. Similarly, in the case of heat transfer, increase in radiating surface would result in a greater total rate of heat transfer, for then more elements of area would be contributing to the total heat flow.

The water analogy breaks down when it attempts to picture the important fact that heat is radiated proportionally to the fourth power of the absolute temperature. Conceivably the pumps might be endowed with this impossible characteristic of increasing their capacity for spraying water proportional to the fourth power of the absolute temperature, but an attempt to force the analogy to this extreme would be absurd.

GENERAL DISCUSSION

Although there exist other important conflicts in the correspondence such as the above, yet an interesting, skilful presen-

tation along these lines should give the student a clearer insight into the methods of heat transfer.

All three methods of heat transfer may contribute to the total heat transference. Under certain other conditions, one method alone may be responsible for the flow of heat. In no instance do we encounter a situation in which heat transfer can be completely prevented. Just so long as a difference in temperature exists, just so long will heat flow take place. Man's ingenuity can but retard the rate of heat transfer by the appropriate use of insulation.

When studying heat flow problems with a view to determining which method or methods of heat transfer are utilized, it is wise for the teacher to constantly make the student consider all three methods. Too often the student is satisfied with pointing out but one method of transfer which may be responsible for only a small fraction of the total heat transfer. For instance, with the ordinary type of frame house, an air space is present between the outside boarding and the inside plaster wall. Heat is transferred across this open air space largely by convection and radiation. By the insertion of mineral wool the nature of the heat transfer is radically modified. Convection currents are practically eliminated, direct radiation is largely intercepted by the mineral wool fill, and conduction through the air and the wool fibres begins to exert a major influence on the heat transfer. With the uninsulated house, convection and radiation are the important methods of transfer; with the insulated house, conduction and radiation are significant. A discussion of one system of transfer without mentioning the other in either case would give an incomplete viewpoint of the transfer.

To picture such situations in which more than one method of heat transfer is contributing to the total heat flow is sometimes confusing to the student. However, by reference to the water analogy, a corresponding set of conditions can be pointed out which may be readily pictured. From this point the student usually will be able to carry the similarity over into the heat transfer problem.

With the water analogy, the uninsulated house condition would correspond to a water transfer mainly by the circulation and spray methods; the insulated house condition would correspond to water transfer mainly by multiple passing and spraying.

In describing certain heat transfer processes, the author has

found it frequently helpful to use the terminology of the water analogy. For example, when discussing the insulating characteristics of the common thermos bottle, the heat transfer process would be explained thus:

Heat from the hot liquid inside is carried or passed to the wall of the container; by multiple passing it moves through the glass to the other side, which is silvered. The heat is then sprayed over to the silvered surface of the opposite glass wall. By multiple passing it travels through this second glass wall. When it reaches the outside surface of the thermos bottle, the heat may be sprayed off or passed outward to nearby circulating or stationary air particles.

In conclusion, it may be advisable to say a word about the use and abuse of analogies. In a recent article,[2] there has appeared an excellent discussion as to the place of analogies in the teaching of freshman chemistry. The arguments presented there, for and against their use, are equally applicable to the present case. A listing of the common objections raised to analogies and the advantages to be gained through their use are given below.

OBJECTIONS

Analogies may

1) be used too frequently,
2) become humorous to the detriment of their instructive value,
3) lack dignity
4) become overloaded,
5) require absurd assumptions,
6) imply non-existent relations,
7) produce reactions entirely foreign to those intended.

ADVANTAGES

Analogies

1) facilitate the grasping and learning of new facts and abstract conceptions by presenting them to the student in terms of his own experience,
2) are advantageous when a mathematical presentation of the subject is out of the question and where the analogy sets up a correspondence that can be reasoned from,
3) are useful in explaining and reenforcing a mathematically obtained concept.

Whether or not an analogy should be used is largely dependent on the teacher. A skilful teacher will discard at the outset any analogies of questionable value. Even the use of the best of analogies will be infrequent. He will eliminate or reduce to a minimum the undesirable consequences arising from the analogy by studying the background of the class, by carefully presenting the analogy, and by checking the subsequent reactions of the class.

[2] Lewis, J. P. *Journal of Chem. Edu.* 10, 10 (1933).

It is hoped that the present article may be wholly or in part of some use to the teacher who occasionally introduces the analogy as a teaching tool and who takes up the subject of heat transfer from a non-mathematical viewpoint.

SOME EFFECTS OF IRRELEVANT DATA IN PHYSICS TEST PROBLEMS

By Robert L. Ebel

Roosevelt High School, Cedar Rapids, Iowa

A common practice in the phrasing and arranging of a physics test problem is to include in the problem only the information which the student needs to use in solving it. A moment of reflection will reveal the fact that any problem so stated does not present a wholly natural, life situation to the student. The solution of a physics problem which arises outside the classroom requires the selection of useful data from a mass of available information. Therefore, if we desire to measure the functional value of the achievement of a high school physics pupil, (that is, its value in terms of his ability to use the principles of physics in solving every-day problems) we should arrange for at least a part of our test problems to contain irrelevant data.

Logic similar to that presented above has led some builders of general achievement tests for high school physics to include irrelevant data in the problems of their tests. It has been assumed that the irrelevant data would improve the problems as measures of the type of achievement just mentioned. However reasonable this logic may appear, it should not be permitted to escape careful experimental checking. We should learn, if possible, the actual effect of irrelevant data on the difficulty and discrimination of individual physics test problems, and the changes which the inclusion of irrelevant data brings about in the measuring characteristics of the test as a whole.

An attempt to provide answers for these questions led to the development of the following experimental procedure. A group of thirty problems relating to the principles of mechanics and heat was selected from the 1932, 1933, 1934 and 1935 Iowa Every-Pupil tests in physics. For each of these problems an alternative statement containing one item of irrelevant data was formulated. In this investigation we used only one form of irrelevant datum, defined as a numerical datum which would

bear a definite relation to some element of the problem in which it occurred, which could be used with the other information given to arrive at a plausible, incorrect answer, but which could not be used to give the correct answer. The italicized portions of the following problems illustrate such irrelevant data.

1. What is the actual mechanical advantage of a block and tackle, if a force *of 2 lbs.* moves 10 ft. while lifting a weight to a height of 2 ft.?
2. What is the horsepower of an engine which, *attached to a wheel and axle having a mechanical advantage of 2,* can lift 1,100 lbs. to a height of 2 ft. in 1 sec.?
3. A spring *weighing 5 gm.* has a length of 6 in. when it supports 10 gm., and a length of 8 in. when it supports 15 gm. How long would it be if it supported 30 gm.?

The problems were divided into two tests, each of which contained both standard and irrelevant data problems. A third test, designed to measure general achievement, was built by selecting eighty-one of the most discriminating verbal items from the same Every-Pupil tests.

The three tests were administered to high school physics students in five Iowa high schools. The teachers were directed to administer the second problem test several days after the first, and to give the achievement test during the intervening days. This order of presentation helped to limit the carry-over of remembered responses from a problem to its homologue.

One hundred and fifty complete sets of papers were returned. From these, certain statistical measures were obtained. The percentage of pupils who failed to answer a given problem correctly was called the index of difficulty for the problem. For a measure of the ability of a problem to discriminate between pupils of high and pupils of low achievement, the biserial coefficient of correlation for each problem was figured both on the basis of the pupils' total scores on the achievement test, and on the basis of their total scores on the problems. This measure is known as the index of discrimination.

A striking variation, from problem to problem, appeared in the effects of the irrelevant data. The difficulty of some problems was greatly increased by the inclusion of irrelevant data. In other problems, an apparent decrease in difficulty accompanied the introduction of irrelevant data. Similar statements can be made with reference to the discriminatory ability of the problems.

These variations may be illustrated by some of the values obtained for the illustrative problems given above. Using the

indices of discrimination figured on the basis of pupils' total scores on the problem tests, we find that the introduction of irrelevant data in problem one increased its discriminatory ability by seventy-nine per cent of its original value, while the introduction of irrelevant data in problem two decreased its discriminatory ability by forty-five per cent of its original value. The difficulty of problem two, however, was increased by ninety-three per cent of its original value, while the difficulty of problem three was decreased by nine per cent of its original value.

No rational basis for these variations could be found in the characteristics of either the original problems or the irrelevant data used. It would thus seem that the effect of irrelevant data is determined specifically in each problem by a complex of relationships between it and the other elements of the problem. Since we tried but one of the many conceivable items of irrelevant data for each problem, we cannot reasonably conclude that it is impossible to improve all problems by the inclusion of irrelevant data. Indeed, it is probable that highly effective irrelevant data could be discovered for each problem. The use of such "effective" irrelevant data in every problem would have resulted in uniform increases in discrimination and, perhaps, of difficulty also. Unfortunately, there is no apparent way of determining, in advance of actual trial, just what the "effective" irrelevant data for a given problem might be. In the whole group of problems, introduction of irrelevant data produced a small average increase in difficulty without producing any significant average change in discriminatory ability.

The correlation between achievement test scores and scores on the standard problems was .719 ± .026, between achievement test scores and scores on the irrelevant data problems was .714 ± .027, and between scores on the standard problems and scores on the irrelevant data problems was .921 ± .008. Evidently the inclusion of irrelevant data in the physics problems did not change, and hence could not improve, the characteristics of the test as a measure of functional achievement. This lack of a significant difference between scores on the two types of problems would be expected on the basis of the wide variation in the effects of irrelevant data on the individual problems. Consistent use of "effective" irrelevant data would probably have produced a marked improvement in the problems.

These findings indicate that the inclusion of irrelevant data

in physics test problems cannot be justified on the basis of improving the discriminatory ability of the items in general, or on the basis of improving the measuring characteristics of the problem test, *unless* the "effective" item or items of irrelevant data for each problem have been selected through trial on a large group of students.

CONSISTENT MEASUREMENT OF LINES AND ANGLES

By Joseph A. Nyberg
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Is the following a good problem: Solve triangle ABC if $a=234$, $b=567$, and $C=32°\ 18'\ 39''$? In other words, if the measurement of a line is correct to n significant figures, how accurately should an angle be measured? The answers found in text books differ considerably. Thus:

1. When the lines are measured correctly to 4 significant figures, let the angle be read to the nearest minute. (Granville's *Trigonometry*, page 183.)

2. Distances expressed to 4 figures call for angles expressed to the nearest tenth of a minute. Distances expressed to 5 significant figures call for angles expressed to the nearest second. (Moritz's *Trigonometry*, pages 93–94.)

3. Angles measured to the nearest minute have about the same accuracy as linear measure correct to 5 figures. (Shuster-Bedford, *Field Work in Mathematics*, page 151.)

4. If angles are given to the nearest minute use 4-place tables; if angles are known to be in error less than 30″ use 5-place tables. (Tracy, *Plane Surveying*, page 373.)

To answer the proposed question we need to review a few facts about significant figures. Although we may use various explanations of significant figures when discussing the topic with ninth grade pupils, we need here the following definition. *The figures of a number are all significant if all the figures except the last are correct, and the error in the last figure is one half unit or less.* Thus .3218 has 4 significant figures if the digits 3, 2, and 1 are correct and the digit 8 is known to lie between $7\frac{1}{2}$ and $8\frac{1}{2}$; that is, the true number lies between .32175 and .32185 and hence the error in .3218 is .00005 or less.

The next item to bear in mind is this: when multiplying two

approximate numbers the product will not have more significant figures than there are in that factor which has the fewer significant figures. Thus, if a number with 4 significant figures (also called 4-figure accuracy) is multiplied by a number with 3 significant figures, the product should be rounded off so as to show only 3 significant figures. Hence we aim to make all measurements *consistent;* that is, all the measurements should have the same number of significant figures. This does not mean that the numbers should have the same number of decimal places. For example, if finding the area of a rectangle whose length measured to the nearest tenth of a foot is 69.2, the width should also have 3-figure accuracy. Hence if the width is less than 10 it should be measured to the nearest hundredth, giving a number like 7.89; but if the width is more than 10 then it needs to be measured only to the nearest tenth.

The original question can now be answered. Suppose that we are dealing with a line and a trigonometric ratio as in the product c sin A.

If the number c has 4 significant figures, then sin A should have 4 significant figures. The angle should therefore be measured so accurately (and only so accurately) that the first 3 figures of sin A are correct and the error in the fourth figure is half a unit or less; that is, the difference between the sine of the true value of A and the sine of the measured value of A must be less than .00005. The question therefore reduces to this one: How accurately must an angle be measured if the difference between the sine of the true value and the sine of the measured value is to be .00005 or less? Further, we seek an explanation that a high school pupil can grasp, not a perfect solution such as we might get by using calculus, difference equations, etc., as in Chauvenet's *Trigonometry*, page 101.

Suppose, for example, that A is about 70° 15′. Is it necessary to know whether the angle is 70° 15.1′ or 70° 15.2′ or 70° 15.3′, or is just 70° 15′ accurate enough? A table of sines shows that sin 70° 14′ = .9411 sin 70° 15′ = .9412 sin 70° 16′ = .9413.

If we call the angle 70° 14′ or 70° 16′ when the true value is 70° 15′ the error in the sine is .0001 which is twice what it should be since c has 4 significant figures. To reduce the error to .00005 the angle must be measured to the nearest half-minute.

A study made in this manner of the tabular differences of sines leads to the following conclusion: When the angle is near 80° the angle should be measured to the nearest minute; when

near 70°, to the nearest half-minute; when near 60°, to the nearest third of a minute; when near 50°, to the nearest fourth of a minute; when near 30°, to the nearest fifth of a minute; and when near 10°, to the nearest sixth of a minute. We see that, unfortunately, no simple rule can be stated that will apply to the entire range of values of the angle.

The corresponding conclusion for a product like $b \cos A$ can be found by using the relation $\cos A = \sin(90 - A)$.

Consider next a product like $a \tan A$ where a has 4 significant figures. Here we must bear in mind that $\tan A$ is less than 1 when A is less than 45° and greater than 1 when A is greater than 45°. Hence, if A is less than 45° an error of at most half a unit in the fourth significant figure means an error of at most .00005, while if A is greater than 45° the error should be at most .0005, not .00005. For example,
$\tan 70° = 2.7475$ $\tan 70°\ 01' = 2.7500$ $\tan 70°\ 02' = 2.7525$.
The differences are .0025. To make the difference .0005 the angle must be measured to the nearest fifth of a minute.

A study of the tabular differences of tangents leads to the conclusion: When the angle is near 80° the angle should be measured to the nearest twentieth of a minute; when near 70°, to the nearest fifth of a minute; when near 55°, to the nearest half-minute; when near 40°, to the nearest tenth of a minute; when near 30°, to the nearest eighth of a minute; and when near 10°, to the nearest sixth of a minute.

The corresponding conclusion for a product like $b \cot A$ can be found by using the relation $\cot A = \tan(90 - A)$.

The conclusion for a quotient is the same as for a product since the rule about the number of significant figures in a quotient is the same as the rule stated for a product.

In the preceding discussion we assumed that the lines were stated with 4 significant figures. If the lines have 5 significant figures then the smallest permissible variation in the angle must be divided by 10; and if the lines have only 3 significant figures the variation in the angle can be multiplied by 10. Thus an angle that must be measured to the nearest fifth of a minute for a line having 4 significant figures must be measured to the nearest fiftieth of a minute if the line has 5 significant figures; and the angle need be measured only to the nearest 2 minutes (10 times $\frac{1}{5}$ of a minute) if the line has only 3 significant figures.

The conclusions are not altered if the work is done with logarithms instead of natural functions since an n-place log-

arithm table gives the same degree of accuracy as non-logarithmic work with n significant figures.

It would be inadvisable to try to abide strictly by these conclusions when making problems for the class in trigonometry. Some compromise, close to the truth, must be adopted. Further, there are other factors to be considered such as: (1) even with a good transit an angle can be measured only to the nearest third or fourth of a minute, (2) the problem should be so stated that the student will get sufficient practice in interpolation, and (3) the nature of the tables must be considered. If the lines have 4 significant figures, the student should work with a 4-place table of logarithms of numbers and a 4-place table of logarithms of the trigonometric functions. In the 4-place table the angles are stated in intervals of 10 minutes, and interpolation can be used for angles stated to the nearest minute but not for angles stated to the nearest tenth of a minute. For an angle like 34° 56.7′ a 5-place table should be used. Considering these factors, the following compromise is suggested:

1. *If the lines show 3 significant figures, the angles should be stated to the nearest 10 minutes.*

2. *If the lines show 4 significant figures, the angles should be stated to the nearest minute and the work should be done with a 4-place table.*

3. *If the lines show 5 significant figures, the angles should be stated to the nearest tenth of a minute and the work should be done with a 5-place table.*

Addenda. A popular misconception is: if the length of a line is stated with 4 figures, as 43.21, the angle should be stated with 4 figures, as 63° 24′. The error is obvious from the fact that the lines are not multiplied by the angles but by the functions of the angles. Thus, 168° 45′ and 11° 45′ have the same sine but the first angle is expressed by writing 5 figures (and has 5 significant figures when expressed as 10,125′), and the second angle by writing 4 figures (and has 3 significant figures when expressed as 675′). If we were finding the length of an arc, the radius and the number of radians in the angle (not the sine or cosine) would need to be considered.

The rules suggested above do not assure us that the product will have as many significant figures as the factors, but are intended only to call attention to the fact that there should be some consistency about the exactness of measurements. Are there any other simple rules?

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Thirty-fourth Meeting

HELD AT WELLESLEY COLLEGE

Wellesley, Massachusetts

Saturday, December 12, 1936

PROGRAM

9:45 Meeting of the Executive Committee.

10:15 Business Meeting.

Report of the Committee on Magazine Literature and New Books.

Report of the Committee on Current Events.

10:30 Display and Demonstration of New Apparatus.

11:00 Some Lecture Experiments in Radio Frequency Oscillations. Professor Louise S. McDowell, Wellesley College.

12:00 Report of the Committee on College Entrance Requirements. Discussion of action to be taken by this Association on the request of the College Entrance Examination Board to participate in the formation of a new syllabus.

12:30 Luncheon at Tower Court.

1:30 Inspection of Laboratories and Apparatus.

OFFICERS

President, LAWRENCE A. HOWARD, High School, East Boston, Mass.
Vice-President, ROBERT W. PERRY, High School, Malden, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, PRESTON W. SMITH, 208 Harvard St., Dorchester, Mass.

COMMITTEES

Executive

GEORGE H. COLMAN, Gloucester High School.
WINTHROP S. DRURY, Middlesex School, Concord, Mass.
EVERETT J. FORD, English High School, Boston.

Magazine Literature and New Books

CARL W. STAPLES, Chelsea High School, Chairman.
THOMAS C. BAILEY, Hartford High School, Hartford, Conn.
KENNETH L. GODING, Attleboro High School.

Current Events

JOHN B. MERRILL, East Boston High School, Chairman.
ANNA E. HOLMAN, The Winsor School, Boston.
CLARENCE W. LOMBARD, Hyde Park High School.

New Apparatus

ROBERT W. PERRY, Malden High School, Chairman.
W. ROSCOE FLETCHER, North High School, Worcester, Mass.
HOLLIS D. HATCH, English High School, Boston.

College Entrance Requirements

BURTON L. CUSHING, East Boston High School, Chairman.

HOMER W. LESOURD, Milton Academy, Milton, Mass.
FRANCIS E. MASON, High School of Commerce, Boston.

BUSINESS MEETING

The following were elected active members,
John L. Clark, Chapman Technical High School, New London, Conn.
Lloyd A. Hechinger, High School, Brighton, Mass.
E. R. Johnson, Thayer Academy, South Braintree, Mass.
Temple C. Patton, Worcester Academy, Worcester, Mass.
Raymond F. Scott, Rindge Technical School, Cambridge, Mass.
Myron C. Gallup, High School, Wakefield, Mass. was elected an associate member.

President Howard spoke of the importance of increasing our membership and urged everyone to help in getting new members.

A letter from the Physics Club of New York proposing that we hold a joint meeting was read by the President. After a number of members had spoken in favor of this and a show of hands indicated that many would attend such a meeting it was voted

That a form letter be sent to all members informing them of the favorable reaction of those present at the 134th meeting toward this invitation and outlining tentative plans and asking for an expression of opinion as to the advisability of holding such a meeting and whether it should be one of our regular meetings or an extra meeting.

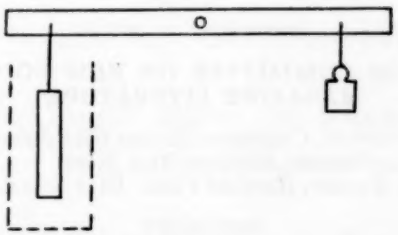
It was voted that the Association extend to Wellesley College and Prof. McDowell its thanks for entertaining us at our 134th meeting and our appreciation of the hospitality shown us.

REPORT OF NEW APPARATUS COMMITTEE

MR. ROBERT W. PERRY, *Chairman, Malden High School*

Mr. Hollis Hatch showed a sample of Dow metal formerly called Magnalium; composition 94% magnesium, 6% aluminum. It is now being used in airplanes and vacuum cleaners where lightness is of primary importance. The specific gravity is 1.79 of this sample or less than any other metal now used commercially.

Specific gravity is usually determined in High School laboratories by using a spring balance or a beam balance. The first is inaccurate and the second inconvenient for weighing a solid under water. For two years I have been trying the following which is inexpensive and capable of three figure accuracy.



I suspend a meter stick at the center, hang a 100g. weight on one side and the solid on the other. When balanced a simple equation of moments

is solved for x. I usually point out that the arithmetic is easier if the unknown is left on an even number and the 100g. weight moved as necessary. This gives an equation like $40x=100(26.8)$ instead of $37.4x=100$ (29.3). The first is obviously less trouble to solve.

When this method of weighing is used to determine the specific gravity of a liquid, the sinker should have a large volume but a weight not greatly more than 100g. It should be unacted upon by the liquid used, be cheap, and easily replaced. Aluminum, porcelain, sulphur and glass might be used but I find the carbon from an old dry cell about right. It also has a nice binding post for suspension by a thread.

Mr. Fletcher showed apparatus, accompanied by drawings, for study of nodes and loops in the sound waves in open and closed pipes.

REPORT OF COMMITTEE ON COLLEGE ENTRANCE REQUIREMENTS

MR. BURTON L. CUSHING, *Chairman, East Boston High School*

The committee reported that the C.E.E.B. has voted to appoint a committee to revise the syllabus for the first or α level (one year) Physics course. This is what the E.A.P.T. has been requesting for the past 3 years.

A letter from the C.E.E.B. was read in which the E.A.P.T. was requested to help in formulating definitions of requirements for the examination in Physics and Chemistry at the second or β level.

Your committee submitted a tentative syllabus which was more general in nature than the old one and it was voted to have copies of this syllabus mailed to each member of the association with a request for suggested changes to be returned in an enclosed stamped envelope.

The committee of the E.A.P.T. was invited to work with a similar committee of the New England Association of Chemistry Teachers to consider the Physics-Chemistry requirements on the second or β level, and met with that committee on the afternoon of Dec. 12 at Wellesley College. At that meeting it was agreed that the Physics committee should make out a tentative outline for one year of Physics with the topics common to both Physics and Chemistry so indicated and for the members from the Chemistry Association to do the same for Chemistry with the common topics indicated, these outlines to be considered at our next joint meeting.

The committee feels that real progress has been made and requests the co-operation of all the members of the association in making suggestions concerning the syllabus which will be mailed to them shortly.

REPORT OF COMMITTEE ON NEW BOOKS AND MAGAZINE LITERATURE

MR. CARL W. STAPLES, *Chairman, Chelsea High School*
MR. KENNETH L. GODING, *Attleboro High School*
MR. THOMAS C. BAILEY, *Hartford Public High School*

NEW BOOKS

New Ways in Photography; Ideas for the Amateur, by Deschin. Whittlesey House, Publishers. $2.75. A real first aid book for the professional as well as the amateur photographer. Contains many suggestions presented

in an interesting and readable way. Many illustrations, well chosen and well explained.

Photography To-day, by D. C. Spencer. Oxford, 160 pp. $1.50. A well-written book. Tells the hows and whys of modern photography. Also gives suggestions on selection of cameras and methods of developing and printing film. A good discussion on optics and light.

The High School Science Teacher and His Work, by Carleton E. Preston. McGraw-Hill Book Company, Inc. 272 pp. $1.60. A very interesting book, especially useful to beginning teachers. It gives a modern view of science, and shows how this view may be used in teaching science.

The Renaissance of Physics, by Karl K. Darrow, Ph.D. Deals with the advance of physics in the twentieth century. Very interesting.

Pascal, the Life of Genius, by Morris Bishop. Reynal & Hitchcock, publishers. $3.50.

Der Kampf des Ingenieurs gegen Erde und Wasser im Grundbau, by Dr. Ing. A. Agatz. Berlin; Julius Springer, publisher. 276 pp. 155 illustrations. 26.40 marks. Deals with soil mechanics and ground water as affecting foundations.

A Manual of Meteorology. A new edition of Vol. 2 of the work by Sir Napier Shaw (assisted by Elaine Audin), 1936. Cambridge University Press. 36s. net. Four volumes (1) Meteorology in History; (2) Comparative Meteorology; (3) Physical Processes of Weather; (4) Meteorological Calculus: Pressure and Wind.

The Study of the History of Science, by George Sarton. Harvard University Press. $1.50. Explains scope and method of study of history of science. Bibliography.

Descriptive Physics, by Sherman R. Wilson. Henry Holt & Co., N. Y., 1936. A new one semester textbook for general divisions in Physics. Very simply and clearly written. Good diagrams. No problems.

Mastery Units in Physics, by Michael N. Idelson, M.A. Colonial Book Company, N. Y. 1936. Paper, $.67; Cloth, $1.00. A good book for review work in preparation for College Entrance Examinations.

Thermionic Emission, by T. J. Jones. Chemical Publishing Company of New York, Inc. $1.25.

Infra-red and Raman Spectra, by G. B. B. M. Sutherland. Chemical Publishing Company of New York, Inc. 1936. $1.25.

Electron Diffraction, by R. Beeching. Chemical Publishing Company of New York, Inc. 1936. $1.25.

Practical Handbook on Electro-plating, Polishing, Lacquering, and Metal Colouring. 12th Edition. Chemical Publishing Company of New York, Inc. 1936. $2.00.

MAGAZINE LITERATURE

Acoustics

"New Science of Sound" by G. W. Gray. *Harper's Magazine*, 173: 421–30, September, 1936.

Air Conditioning

"Railroad Cooling; Eastman suggests other passenger improvements." *Business Week*, p. 37, June 20, 1936.

"Conditioned Air?" by P. H. Smith. *Scientific American*, 155: 80–3, August, 1936.

Aeronautics

"Hindenburg" by A. Klemin. With diagrams. *Scientific American*, 154: 330–2, June, 1936.

"Up Ship! Zeppelin Travel" by M. G. Winn. *Readers' Digest*, 29: 20, September, 1936.

"Visit to the Hindenburg" by A. Klemin. *Scientific American*, 155: 238, October, 1936.
"Future Titans of the Sky." *Popular Mechanics*, p. 882, December, 1936.

Amplifiers

"Amplifier for Amateur Theatrical Sound Effects." *Popular Mechanics*, 66: 738–9, November, 1936. With diagrams.
"How Power Amplifier is Easily Made" by H. G. Cisin. *Popular Science Monthly*, 129: 59, October, 1936.

Astrophysics

"Eclipse in Ak Bulak" by Menzel & Boyce. *Technology Review*, November, 1936, p. 19. Illustrated. Harvard-M. I. T. Expedition to Russia Reports on its Experiences and Results.
"Radio Data During the Recent Solar Eclipse." *Science*, 84: sup. 7; August 14, 1936.

Atmosphere

"Exploring Up and Down." With diagrams. *Popular Mechanics*, 66: 530–3, October, 1936.

Atomic and Molecular Physics

"Secrets of the Atom: Work of the Cavendish Laboratory" by J. W. N. Sullivan. *Fortune*, 145: 713–20, June, 1936.
Several Articles on Atomic Physics. *Physical Review*, November 1, 1936.
"Nuclear Chemistry, the Neutron and Artificial Radioactivity" by W. D. Harkins. Tables. *Science*, 83: 533–43, June 5, 1936.
"Another Cyclotron." *Scientific American*, 155: 95. August, 1936.

Automobile

"Automobile et Touriame." *L'Illustration*, October 3, 1936. Nearly entire number.
"Why your Car Needs an Oil Filter." *Popular Mechanics*, December, 1936, p. 866.
"Are Engines Behind Just Ahead?" A fine discussion of relative merits of front engine and rear engine automobiles. *Automobile Trade Journal*, November, 1936, p. 20.
"Hypoid Service Highlights." *Automobile Trade Journal*, November, 1936, p. 28. A discussion of the hypoid gears on many of the 1937 cars. A discussion of three opinions as to oiling practice best suited to these gears. Numerous photographs plainly illustrating construction, types, and uses of these gears.
"Are Modern Cars Safe?" by A. Klemin. Tables. *Scientific American*, 155: 61–4, August, 1936.
"Auto as a Vitalizing Factor: Automobile Week, Cleveland East Technical High School" by J. G. Quick. *Ind. Arts and Vocational Education*, 25: 271–5, Septemaber, 1936.

Aviation

"Training Pilots to Fly the Beam" by A. F. Bonnalie. *Scientific American*, 154: 322–4, June, 1936.
"United Lines Blind Landing a Long Step Toward Safe Flight." *News Week*, 7: 30, May, 1936.
"Aviation in the High School" by J. W. Geachins. With diagrams. *Ind. Arts and Vocational Education*, 25: 326–8, August, 1936.
"America from the Air." *Scientific American*, 155: 211, October, 1936.
"Airplane Carriers; High Speed Naval Aircraft Carrier" by A. Klemin. *Scientific American*, 155: 32, July, 1936.

"Progress in Two-Row Engines" by A. Klemin. *Scientific American*, 155: 33, July, 1936.
"New Aviation Fuel" by A. Klemin. *Scientific American*, 155: 154, September, 1936.
"Automatic Variable Pitch Propellers" by A. Klemin. *Scientific American*, 155: 154, September, 1936.
"Latest Hammond; the Model Y" by A. Klemin. *Scientific American*, 155: 94, August, 1936.
"Exporting the Art of Sound-proofing" by A. Klemin. *Scientific American*, 155: 93, August, 1936.
"My Flight Across Antarctica," by Lincoln Ellsworth. *National Geographic Magazine*, July, 1936, pp. 1–36.

Biophysics

"Nature's Airplanes" by S. F. Aaron. *Scientific American*, December, 1936, pp. 338–39.
"Effect of Electric Shock on the Heart" by L. P. Ferris. *Bell Laboratories Record*, June, 1936, pp. 318–24. Illustrations, graphs, etc.

Biography

"Namen Wurden Physikalische Begriffe" Zur Erinnerung an Ampère (gest. 1936) und Fahrenheit (gest. 1736). *Illustrierte Zeitung*, (Leipsic) June 11, 1936, p. 795.
"Modern Alchemy." *Atlantic Monthly*, 157: 737–41, June, 1936.

Construction

"Road Bridge Over the Mäler Lake at Stockholm." (Bridge has various interesting features of construction.) *Engineering*, November 6, 1936, pp. 493–96.

Electricity

"Current for Electroplating" by K. Ford. (With diagrams.) *Popular Science Monthly*, 129: 62–3, November, 1936.
"The Story Behind Your Light Bill" by Malcom G. Davis. *Technology Review*, May, 1936, p. 342.
"A.C. Rectifier Recharges Dry Cells." *Modern Mechanics*, December, 1936, p. 64.
"Electroplate Metal with Electro-Pad Plater." *Modern Mechanics*, December, 1936, p. 91.

Geophysics

"Exploring Yukon's Glacial Stronghold" by Bradford Washburn. *National Geographic Magazine*, June, 1936, pp. 715–48.
"Gravity Anomalies in the United States" by E. Glennie. With diagrams, maps, and tables. *Journal of Geology*, Oct.–Nov. 1936, pp. 765–82.
"On Mapping Underground Geology." *Engineering and Mining Journal*, November, 1936, pp. 557–61.
"Ice Troglodytes and Their Home Comforts" by A. R. Glen, Leader of the Oxford University Arctic Expedition, 1935–6. *Illustrated London News*, October 10, 1936, pp. 608–11.
"Natural Electric Currents in the Earth" by O. H. Gish. *Science Monthly*, 43: 47–57 (With maps and diagrams), July, 1936.
"Is the Universe Running Down? The Second Law of Thermodynamics" by W. F. G. Swan. *Science Monthly*, 42: 498–516, June, 1936.

General Physics

"Accomplishments and Future of the Physical Sciences" by W. R. Whitney. *Science*, 84: 211–17, September 4, 1936.

"Trends in Modern Physics" by Prof. Allan Ferguson. *Nature*, November 7, 1936, p. 785.

"Science and the Fine Arts." (Does Technical Education Debase Esthetic Appreciation?) by Ralph G. Hudson. *Technology Review*, May, 1936, p. 339.

Gliders

"Gliders of Rubber" by A. Klemin. *Scientific American*, 155: 94, August, 1936.

Gravity

"Can the Laws of Gravity be Overcome?" (The Famous Yoga "Levitation" of India Tested by Photography). *London Illustrated News*, June 6, 1936, pp. 993–95.

Heat

"The Karlsruhe Cryogenic Institute (10th Anniversary)." *Ice and Refrigeration*, November, 1936, p. 394.

"The Approximate Connection of Boiling Points for Variation in Pressure." Comment on formula. *Science*, November 20, 1936, p. 459.

"Heat Loads of Electrical Equipment." (H & V's Reference Data –89.) *Heating and Ventilating*, November, 1936. Opposite p. 58. 2 pages of data.

"Pulverized Fuel Foundry Equipment" II. *Mechanical World*, November 6, 1936, p. 469.

"Coldest Cold" by D. H. Killeffer. *Scientific American*, 155: 163, September, 1936.

"The New in Heating." *Scientific American*, December, 1936, pp. 334–36.

"Heat Transfer in Evaporation and Condensation, Part II." Lectures 4, 5, and 6 in series. Lectures 1, 2, and 3 on Evaporation are in the October issue. *Mechanical Engineering*, November, 1936, pp. 729–39.

Historical

"Historic Scientific Instruments Exhibited at Cambridge" by Dr. R. T. Gunthes. *Illustrated London News*, June 13, 1936, pp. 1052–3.

"Monsters of the Deep" (Regarding "Freak Ships"). *Illustrated London News*, June 13, 1936, pp. 1044–5.

Hydraulics

"Rush Dams to End Drought Menace." *Modern Mechanics*, December, 1936, p. 80.

Invisible Radiations

"Up to Date on Cosmic Rays" by J. Harrington. *Scientific American*, 155: 142–4, September, 1936.

"Balloons for Cosmic Ray Research" by Klemin. *Scientific American*, 155: 156–7, September, 1936.

"Cosmic Rays Trapped in Mountain-Top Laboratory on Summit of Mt. Evans, Colorado" by J. E. Lodge. *Popular Science Monthly*, 129: 13–15, November, 1936.

"New Types of Atom Destruction." *Science*, 84: sup., p. 6, August 28, 1936.

"X-Rays-X-ray tubes (1,200,000 volt) now being built for Miller Hospital, St. Paul." *Science*, 83: sup. 6, June, 1936.

"Use of X-Rays in Testing Materials." *Science*, 84: sup., p. 10, July 3, 1936.

"Greater than all Available Radium." *Technology Review*, November, 1936, p. 8. New Electrostatic generator for short-wave x-rays. With diagrams.

Light

"The Miracles of Light" *Popular Mechanics*, December, 1936, p. 820.

"New Safeguards for Ships in Fog and Storm" by George R. Putnam. *National Geographic Magazine*, August, 1936, pp. 169–200. Thirty Illustrations.

"Problems of Highway Lighting" by L. A. S. Wood. *The Electric Journal*, October, 1936, pp. 459–65.

"New Developments in Mercury Vapor Lamps" by A. B. McKenna. *The Electric Journal*, October, 1936, pp. 438–42.

"Polarized Lighting System for Safer Driving." *Popular Mechanics*, December, 1936, p. 888.

"Blinders for the Motorist." *The Automobilist*, September, 1936, p. 8. (Discussion of change in visibility for auto driver. Diagrams show decrease in angle of visibility from 1900–1936 from 50° to 4°.) Artist's conception of rear engine cars.

"High Efficiency from New Lamps" (Mercury lamps known as fluorescent and capillary types). *Scientific American*, 155: 15, July, 1936.

Metals

"A Monument to Cast Iron" by LeRoy W. Allison (U. S. Capitol dome). *The Iron Age*, November 19, 1936, p. 44 (Illustrated).

"Little Long Lac Gold Area" by A. H. Hubbell. *Engineering and Mining Journal*, November, 1936, p. 571. (Recent promising finds.)

"Metal Casting in Aluminum and Bronze." *Modern Mechanix*, December, 1936, p. 110.

Meteorology

"Airplane Weather Observation Stations." *Science*, 84: 240–1, September 11, 1936.

"Studies of Hurricane Weather." *Science*, 84: sup., p. 10, September 4, 1936.

Philosophy

"Science versus Absolutism" by T. Swawn Harding. *Sewanee Review*, October–December, 1936, p. 472.

Photoelectricity

"New Reproducer System for Small Theatres" by G. Puller. *Bell Laboratories Record*, September, 1936, pp. 25–29.

Photography

"Summer Night Photography by Moonlight; an Astronomer's Device" (30 to 90 seconds exposure). *Illustrated London News*, May 30, 1936, pp. 956–7.

"Films" (Clear discussion on regular, ortho- and panchromatic films, also color sensitivity of a film, sheet of emulsion, grain, contrast, and trade hints). *Nature Magazine*, October, 1936, p. 194.

"Photographing Burned Documents." *Scientific American*, 154: 339, June, 1936.

"Shooting with Speed Gun" by W. V. Mitchell. *American Photography*, 30: 432–7, July, 1936.

"Home-made Flood Lamp" by N. Cummings. *American Photography*, 30: 475–6, July, 1936.

"Photoelectric Timing in Projection Printing" by F. G. Brockman. (With Tables and Diagrams.) *American Photography*, 30: 604–10, September, 1936.

"Teaching Photography in College" by J. B. Wertz. *American Photography*, 30: 422–8, July, 1936.

"Heat Photographs." *Science*, 83: sup., pp. 6–7, September 25, 1936.

Radio

"Directive Antenna Solves Coverage Problem." *Bell Laboratories Record*, September, 1936, pp. 17–20.

"A New 5-kw. Broadcast Transmitter" by L. G. Young. *Bell Laboratories Record*, November, 1936, pp. 72–75.

"Remote Control for Radio Receivers" by J. C. Bain. *Bell Laboratories Record*, October, 1936, pp. 49–51.

"Four-tube Transceiver for 5 Meters." *Popular Mechanics*, 66: 737, November, 1936.

"One to Ten Meter Receiver." *Popular Mechanics*, 66: 577, October, 1936.

"Portable Short-Wave Transmitter Built to Operate on 6 Volt Battery" by J. Carr (Diagrams). *Popular Science Monthly*, 129: 58–9, Novem ber, 1936.

"An All-Purpose Radio Receiver for Mobile Application" by K. O. Thorp. *Bell Laboratories Record*, September, 1936, pp. 2–6.

"High Fidelity Radio Broadcasting." *Bell Laboratories Record*, June, 1936, pp. 325–29.

"Multi-frequency Radio Transmitters" by J. B. Bishop. *Bell Laboratories Record*, July, 1936, pp. 350–54.

"Dowsing for Cable" by R. I. Crisfield (Exploring coil). *Bell Laboratories Record*, August, 1936, pp. 383–4.

Radium

"The Granodiorite Laccolith of the Malka River (No. Caucasus) and its Content of Radium" by S. P. Soloviev. (Diagrams.) *American Journal of Science*, November, 1936, pp. 380–91.

Roads

"Une Nouvelle Route Transandine au Pérou." *L'Illustration*, August 22 1936, p. 504.

Steamships

"R.M.S. 'Queen Mary' Number." *Illustrated London News*, May 23, 1936.

Stratosphere

"Scientific Results of the Stratosphere Flight" by Capt. Albert W. Stevens (Fifteen illustrations). *National Geographic Magazine*, May, 1936, pp. 693–714.

"Commercial Stratosphere Flying" (London–New York in six hours). *Illustrated London News*, October 10, 1936, p. 631.

Supersonic Waves

"The Hartmann Acoustic Generator." *Engineering*, November 6, 1936, pp. 491–2.

Telephony

"Buried Telephone Wire" by D. A. Quarles. *Bell Laboratories Record*, November, 1936, pp. 66–71.

Teletype

"Teletypewrite Exchange Systems" by G. A. Locke. *Bell Laboratories Record*, September, 1936, pp. 7–10.

Television

"Les Premiers Regards de la Telévision." *L'Illustration*, September 5, 1936, pp. 8–16.

Transportation

"Der Kampf um die Erschliessung der Arktis" von Walther Pahl. *Deutsche Rundschau*, October, 1936, pp. 1–12 (With Maps).

"Transportation, its Place in the National Economy, its Problems, and its Future Development." 5 Articles. *Technology Review*, July, 1936.

"Trains of To-day and Tomorrow" by J. R. Hildebrand (With fifty illustrations). *National Geographic Magazine*, November, 1936, pp. 535–89.

"Weight Saved in New Hiawatha Cars." *Railway Mechanical Engineer*, November, 1936, p. 467. (Plans, pictures, etc.)

Laboratory Technique

"Care of Electrical Measuring Instruments in the School Shop" by H. Trelease. *Industrial Arts and Vocational Education*, 25: 184–90, June, 1936.

REPORT OF THE COMMITTEE ON CURRENT EVENTS

MR. JOHN B. MERRILL, *Chairman, East Boston High School*

Nobel Prize

The 1936 award of the Nobel Prize in Physics was made jointly to Dr. Carl D. Anderson, of the California Institute of Technology, and Dr. V. F. Hess, of the University of Innsbruck. Dr. Anderson is the discoverer of the positron and Dr. Hess discovered cosmic radiation.

World Power Conference

The third World Power Conference was held in Washington in September. Three thousand delegates from fifty-four nations were in attendance. One faction contended that the energy of the world should be supplied by private industry, with a minimum of regulation and interference by the government, while another group believed that the government, representing the people, should do the job. In the discussion of future power prospects it was pointed out that the potential hydroelectric possibilities have been developed to only a comparatively small extent. In regard to the use of power, it was stated that power may be used for purposes that constitute only a waste of what the engineers have so economically produced.

Meeting of American Institute of Physics

On October 29 and 30 the American Institute of Physics met in New York. Industrial physicists urged that there be some changes in our science education, saying that industry needs men trained in the fields of optics, magnetism, and acoustics which are not sufficiently emphasized in the schools. Students are attracted by the work of the more prominent physicists in the realm of cosmic rays, etc.

Williams College Mark Hopkins Centenary Celebration

Prof. J. C. Slater called attention to the reunion of the sciences of physics and chemistry after years of separation. Davy and Faraday worked interchangeably in the two fields. Now physics is coming to the aid of chemistry in providing more powerful ways of observing matter and in interpreting the structure of matter in terms of the basic laws of nature.

Pontifical Academy of Science

A new Pontifical Academy of Science was initiated by the Pope on Oct. 30. It was announced that the members had been elected solely for scientific achievement. There are seventy members, six being from the United States.

Research by Railroads

The railroads of the country continue to modernize their service by physical research by themselves and in conjunction with many equipment manufacturers. Air conditioning, lighting, automatic signalling, and power are some of the fields that are being thoroughly investigated. In the latter phase steam, Diesel, and electrical power units have been significantly improved, with streamlining of all three being particularly investigated. Speeds of 90 and 100 miles per hour are regularly employed. It is said that the driver of the most modern trains need not look out his window to know exactly what clearance he has ahead. Attempts are being made to combine rail and highway trucking in a single unit having both pneumatic tires and flanged wheels. The latter are raised and lowered readily according to requirements.

The first all-metal, steamlined milk tank car has recently been placed in service. It consists of two 12,000 quart glass lined tanks set in cork insulation six inches thick, the whole being surrounded by a steel shell. It is expected to be able to transport milk to a distance of about 200 miles with not more than a degree change in temperature.

Henry Hudson Bridge

The new Henry Hudson Bridge over the Harlem River in New York is a notable engineering achievement. Its 800 foot span is the longest hingeless arch and the longest arch of plate-girder construction in the world.

Television Demonstration

The first demonstration of television to be conducted under practical working conditions was given in New York on November 6. A new twelve-inch receiving tube was employed, giving a reproduction on a 7½ by 12-inch screen. The program originated in a studio at the RCA Building, was put out from a transmitter on the Empire State Building, and was received in a room on the 62nd floor of the RCA Building. In field tests carried on since last June, a receiver 45 miles from the Empire State Building has operated successfully. It is said that RCA is planning to advance from 343-line scanning to 441.

Modern Rail Laying

Continuous welded rails are now being employed in various places on the railroads. These are fabricated at the shops, transported on long trains of flat cars, and unloaded into position, practically. As an example, mention might be made of a 4,000 foot stretch made for the Blossburg Tunnel on the Northern Pacific. The two parallel lengths were carried on a train of 90 flat car axles under the rails to facilitate unloading. This was done by separating the train in the center and pulling it apart, allowing the long stretch of rails to sag down between.

Mechanical Cotton Picker

Patents numbered 2058513 and 2058514 have been granted to Mack D. and John D. Rust of Memphis, Tenn., for a mechanical cotton picker that can do the work of 100 hand pickers. It has two picking units and it straddles two rows of plants as it moves along. The cotton is stripped from the unopened bolls, and a mechanical gleaner picks up any that has been dropped. Its speed can be varied to suit any type of field and growth. The machine makes it possible to plant rows closer together than heretofore.

Centrifuge

Centrifuges of the type used by Prof. Svedburg of the University of Upsala continue to be installed at various places. He investigated the size

and structure of the protein molecule, and the one at the university of Virginia has been used to separate the isotopes of gases. 60,000 to 70,000 P.R.M. are being employed. Two new ones have recently been contracted for in this country.

"Fairbottom Bobs"

Every person interested in physics ought to see the Newcomen engine called "Fairbottom Bobs" at Henry Ford's Dearborn museum. It is now workable, although it is probably the oldest engine in existence. It was brought from England and set up here with only a very small amount of new material being needed.

Electrophotography

For studying the breakdown of insulators a moist-oil-immersed film is placed in a light-proof housing together with the insulator being tested. When a high potential A.C. is applied a photographic record of the location and the intensity of the breakdown is obtained.

Flying by Sound

A wind-driven magneto on the wing of an aeroplane has been adapted to the production of a tone which varies with the changing altitude of the plane. Should the plane nose down at all, the speed of the magneto is increased and the pitch of the tone rises.

Noiseless Electric Switch

The General Electric Laboratories have produced a switch which will eliminate the time-honored click. Two shallow chrome steel cups, sealed together with a piece of glass, form the contacts. A ceramic disc with a hole in it, and a few drops of mercury, partly fill the enclosure between the cups. The device is filled with hydrogen, and sealed by welding. In the off position, the hole in the disc is above the mercury level. A rotation of 20 degrees to the on position, permits the mercury to flow through the hole and make the electrical connection. One of these switches has turned a 200-watt lamp on and off some 65 million times in the last two years with no signs of wearing out or failure.

X-Ray Generator

An electrostatic generator of the Van de Graaff type, capable of producing penetrating short wave X-Rays at a potential of one million volts, has been built for the Huntington Memorial Hospital. The more penetrating rays, similar in their effects to the gamma rays from radium, are better able to treat deep seated malignancies, and are more specific in their action on diseased tissue than the relatively low voltage rays now in general use. This machine is capable of producing a greater intensity of these rays than the combined output of all the radium in the world. The power input of about 15 kilowatts is small compared with other high voltage types. Since the target is at ground potential, it will be possible to treat patients with complete safety at distances as small as one centimeter from the target.

Modern Steam Plants

It is stated that modern steam power plants are less costly than most hydroelectric installations.

Methane Gas Engine

The Greencastle, Ind., sewage disposal plant uses a Ford V-8 engine as the source of power for a blower which supplies air for the aeration of the sewage. Heat from the cooling system is used to maintain a favorable

temperature in the septic tank. Here methane is generated and piped to the engine as its sole fuel. It runs 24 hours a day, seven days a week at 1,500 R.P.M. Several other sludge gas engine plants have been put into operation here and abroad since 1927.

Blue Color of Water

An investigation of the blue color of water in Crater Lake, Oregon, has been conducted by Dr. Pettit of Mt. Wilson for the Carnegie Institution. His conclusion is that it is not caused by particles in the water. The red rays filtered out in the scattering process in the water, leaving the blue dominant.

Asbestos Fabric

From Russia comes a new fabric knitted from spun threads of asbestos. Suits made from it weigh about four pounds. These were tested by picking up and bending red hot rods.

Anniversary of First New England Passenger Train

A train of converted stage coaches was hauled over wooden rails between Bangor and Old Town Maine, November 29, 1936. Wood was burned under the boiler and the cars were heated by ten gallon cans of hot water. Speed is not mentioned in the report.

Giant Atom Smashing Gun

A huge seventeen-foot vacuum tube using a million volts has recently been completed at the University of Michigan.

Age of the World Placed at 170,000,000 Years

Dr. Alfred C. Lane describes to American Philosophical Society how age of rock, etc., is measured in terms of radioactive disintegration.

Bigger and Not Better Bands

John Redfield, authority on music, and fellow of Acoustical Society of America, reports that bands occupying platforms exceeding 70×70 feet will be inefficient on account of the lagging due to speed of sound.

Scientific Men in Greater Demand

Dr. Crawford, director of Department of Personnel Study and Bureau of Appointments, Yale University, reports greater demand for men trained in engineering and science than for others without technological ability.

Dozen Greatest American Inventors Chosen

Fulton, Whitney, Morse, Goodyear, Bell, McCormick, Howe, Westinghouse, Edison, Merganthaler, Hall, Wright, named at the one hundredth anniversary of the American Patent System.

Red Tail Lights May Mark Rim of Creation

Mysterious reddish phenomena near seeing limits of 100-inch Mt. Wilson observatory telescope may mark edge of universe. Astronomers await more powerful telescopes before suggesting significance of strange spectacle.

Dr. Einstein Again

Famous scientist discovers that space near stars constitutes lens for better observation of more distant stars, planets, etc.

SOME LECTURE EXPERIMENTS IN RADIO FREQUENCY OSCILLATIONS

PROF. LOUISE S. MCDOWELL, *Wellesley College*

However unsuccessful we may be, most of us probably regard the encouragement to practice the art of thinking as one of the most important aims of a course in physics. For some twenty years I have been teaching to college juniors and seniors a course in electromagnetic oscillations, or radio as it is popularly known. Aside from the importance of the content, the course has three values which seem to me of great importance: it offers the student in the laboratory opportunities to demonstrate and cultivate the independence of thought, ingenuity and initiative required for research; it gives familiarity with the use of a new tool, the electron tube, which has had an influence on the advance in science comparable with the advance that followed the invention of the telescope, the microscope and the spectrometer; it reviews principles already learned and shows how the phenomena of electricity may be correlated with those of mechanics, sound and light. The experiments I am showing this morning have been selected to illustrate this last point.

I hope that the title of my talk has not led you to expect new or spectacular demonstrations. The experiments are doubtless but variants of experiments with which you are all familiar. It is indeed fortunate for us as teachers of science that experiments and problems are not copyrighted, however demoralizing to our morals may be the practice of utilizing the clever ideas of our colleagues.

For some of these experiments and especially for the continuously variable inductance and the modification of Lodge's diagrammatic circuit, I am indebted to Professor Merritt of Cornell whose Friday lectures on "Recent Advances in Physics" were famous among Cornellians twenty-five years ago for the beauty and novelty of the demonstrations. Those lectures awakened in many of us an eager desire to experiment for ourselves in these new fields. Another remarkable teacher to whom I should like to express my indebtedness is Professor W. S. Franklin whose use of analogues in electricity and mechanics I have found of inestimable value in the teaching of electricity. Some of you will recall his lecture before this association.

The first experiment is one I use also in the course in general physics to show that electric waves must be caused by electric vibrations. To prove that the discharge of the Leyden jar may be oscillatory I use first a small coil with a 4-volt bulb which gives the chance to review the fact that the induced electromotive force depends upon the rate of change of the lines of force through the coil. The fact that when the coil is held in front of the 5-turn coil in the primary the lamp lights despite the very small number of turns in each coil indicates that the lines of force and hence the current in the primary must be varying with astonishing rapidity. This suggests

that it is an alternating current of very high frequency. The coil may also be used to map the lines of force about the primary coil.

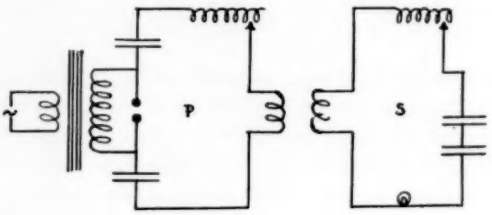


FIG. 1

The use of resonance to show that the discharge is oscillatory affords the chance to study the expression for $n=\frac{1}{2\pi\sqrt{LC}}$ or the equivalent, $T=2\pi\sqrt{LC}$, and to compare it with $T=2\pi\sqrt{m/f}$. With the variable L it is easy to show that changing the number of turns alters the period and to recall that since inductance produces a back electromotive force the effect is like the resistance offered to change of motion as expressed in Newton's second law

$$f \propto ma$$
$$E \propto Ldi/dt.$$

If inductance corresponds to mass the smaller the inductance the less the inertia and hence the more rapid the acceleration of the electrons and the shorter the period of oscillation. It is also easy to show that since

$$\frac{Q}{C}=V$$

$1/C$ gives the electromotive force per unit charge displaced just as f gives the force per unit displacement in simple harmonic motion. Hence by analogy,

$$T=2\pi\sqrt{\frac{L}{1/C}}=2\pi\sqrt{LC}.$$

By increasing or decreasing C in the secondary the corresponding change in L necessary to keep frequency constant can be shown.

To illustrate the fact that electrical circuits as well as sounding bodies have overtones, I use a long coil with distributed inductance and capacitance coupled to the same primary circuit. This serves to review the subject of overtones in organ pipe. The electrons may be visualized as flowing to the top until the large negative charge repels and therefore stops other electrons. If the bottom is connected to earth it will be a potential node and current antinode. The flow of electrons is made evident by a lighted lamp in the ground connection. Disconnecting the lamp prevents the flow. The coil then becomes the analogue of two closed organ pipes with their open ends together. The fact that where motion is greatest pressure change

is least, i.e., that motion node and pressure antinode occur at same place and vice versa can be shown more easily than in the case of organ pipes.

To illustrate the fact that current is rate of flow of charge and depends therefore not only upon the number of electrons flowing along a wire but upon how fast they flow this diagrammatic circuit is especially well adapted. A fine steel wire is placed from *A* to *B* to *C*. *AB* glows brightly when the switch is closed, *BC* remains cool. The students can be encouraged to decide that the same charge flows into the condenser when it is charged as flows out when it is discharged but that it flows into the condenser in about one two-hundred-fortieths of a second whereas it flows out in perhaps one fifteen-millionth of a second. Hence the high frequency current will be many times as great as the low frequency.

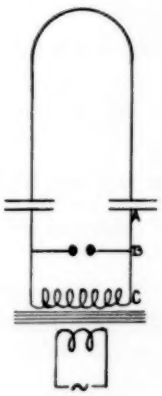


FIG. 2

This circuit also can be used to illustrate the effect of inductance and resistance in parallel by the lighting of a lamp held across the loop. A considerable current will flow through the lamp despite the negligible resistance of the large wire of the loop.

The fact that a condenser offers very little hindrance to the flow of high frequency alternating currents may be shown by the use of a secondary circuit consisting only of small coupling coil, condenser and 11-volt lamp. By adjusting the coupling until the light is normal when the condenser is cut out and then introducing one, two, three or more condensers in series one can easily show that $0.1\mu f$ produces little effect and emphasize again the fact that $Q/C = V$ and that Q will be small because in the high frequency current relatively few electrons are flowing very fast. By contrast, in the 110-volt circuit the introduction of even $50\mu f$ will appreciably lessen the light of the lamp.

These experiments illustrate but a few ways in which students can be encouraged by such a course to reconsider the meaning of familiar principles and to correlate phenomena.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1460–8, 1470–1. *G. S. N. Ayyar.*

1463. *Daniel Finkel, N. Y. C., David Rappaport, Chicago, Hugo Brandt, Chicago.*

1466, 68, 69, 70, 71. *M. W. Keller, Purdue University.*

1469 *A. R. Haynes.*

1470. *Daniel Finkel, W. E. Buker, Joseph Peek, Portland.*

1466–71. *Raymond Schnepp, St. Mary's University of San Antonio.*

1461–65. *Charles W. Trigg.*

1472. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Given $\triangle ABC$, $\triangle DEF$, and fixed point D' on side AB of $\triangle ABC$. Construct $\triangle D'E'F' \backsim \triangle DEF$ so that E' and F' are respectively on sides BC and CA of $\triangle ABC$.

Solution by the proposer.

Construction: Construct $D'X$ cutting BC at X so that $\angle BXD' = \angle F$.
Construct XF' cutting AC at F' so that $\angle D'XF' = \angle E$ and $\angle BXD'$ and $\angle D'XF'$ do not overlap.
Circumscribe a circle about $D'XF'$ cutting BC again in E'.
Draw $D'E'$, $E'F'$, and $F'D'$. $\triangle D'E'F'$ is the required $\triangle$.

Proof: $\angle D'F'E' = \angle BXD' = \angle F$ and $\angle D'E'F' = \angle D'XF' = \angle E$
$\therefore \triangle D'E'F' \backsim \triangle DEF$.

Note: In general, there are two solutions depending on the two positions of $D'X$.

Other solutions were offered by Howard R. Harold, Tonkawa, Okla., A. R. Haynes, Tacoma, Wash., Seymour J. Sherman, New York, W. E. Buker, Pittsburgh, Pa., and Hyman Marcus, New York City.

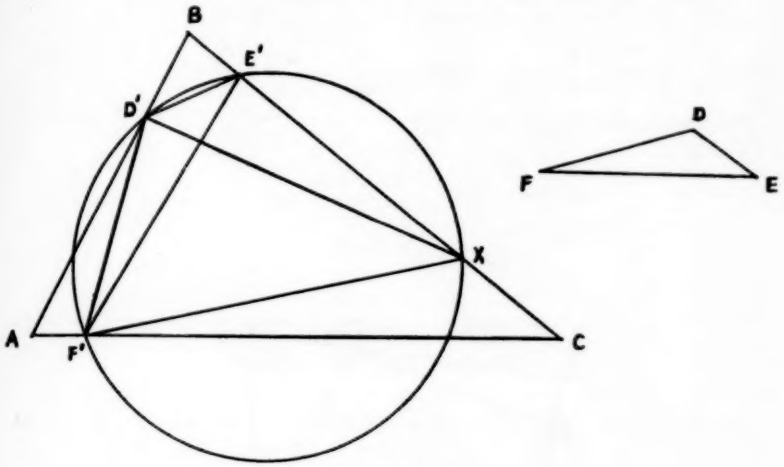


FIGURE 1472

1473. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

The sum of the diagonals of a parallelepiped is smaller than one half and greater than one third of the sum of the diagonals of its faces.

Solution by W. E. Buker, Pittsburgh.

Let d = sum of diagonals of the parallelepiped.
Let f = sum of diagonals of faces of the parallelepiped.
Let m = sum of medians of the tetrahedron circumscribed by the parallelepiped.
Let c = sum of edges of the tetrahedron circumscribed by the parallelepiped.

By referring to Altschiller-Court's *Modern Pure Geometry* (Macmillan) sections 180, 181, 190, and 198, the following relations are established.

1. $e=\frac{f}{2}$
2. $\frac{4}{9}e<m<\frac{3}{4}e$.
3. $m=\frac{3}{4}d$. From 2 and 3, since $\frac{m}{2}=\frac{d}{3}<d$, we obtain,
4. $\frac{3}{4}e<d<e$. From 1 and 4, since $\frac{1}{2}f=\frac{3}{4}e$, it follows that
5. $\frac{1}{2}f<d<\frac{1}{2}f$.

A similar solution was also offered by the proposer.

1474. *Proposed by G. S. N. Ayyar, India.*

$ABCD$ is a quadrilateral with sides, AB, BC, CD, and DA divided by P, Q, R, and S respectively so that ratios $PA:PB=QB:AC=RC:RD$

$=SD:SA=m:n$. Find the areas of the quadrilateral $PQRS$ in terms of m and n, and the area, K, of $ABCD$.

Solution by the proposer.

$$\frac{PA}{PB}=\frac{QB}{QC}=\frac{RC}{RD}=\frac{SD}{SA}=\frac{m}{n}.$$

Then $\frac{PB}{PA}=\frac{n}{m}$ and $\frac{PB}{AB}=\frac{n}{m+n}$. Similarly $\frac{BQ}{BC}=\frac{m}{m+n}$.

The area of $\triangle BPQ=\frac{1}{2}BP\cdot BQ \sin B$

$$=\frac{mn}{2(m+n)^2}\cdot AB\cdot BC\cdot \sin B$$

$$=\frac{mn}{(m+n)^2}\times\text{area of } \triangle ABC.$$

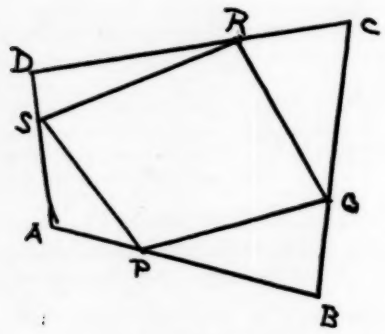


FIGURE 1474

Similarly the area of $\triangle RDS=\frac{mn}{(m+n)^2}\times$area of $\triangle ABC$.

$\therefore\ \triangle BPQ+\triangle RDS=\frac{mnK}{(m+n)^2}$, where K is the area of the quadrilateral $ABCD$.

In the same way $\triangle CQR+\triangle ASP=\frac{mnK}{(m+n)^2}$.

Hence the four $\triangle$'s BPQ, CQR, RDS, ASP are together equal to $\frac{2mnK}{(m+n)^2}$.

$\therefore$ area of $PQRS=K\left\{1-\frac{2mn}{(m+n)^2}\right\}$

$$=K\cdot\frac{m^2+n^2}{(m+n)^2}.$$

Solutions were also offered by Samuel Schwartzberg, N. Y. C., W. E. Buker, Pittsburgh, David Blackwell, University of Illinois, Hyman Marcus, New York, and Charles W. Trigg, Los Angeles.

1475. *Proposed by Charles W. Trigg, Los Angeles.*

In an inscriptable convex quadrilateral the diagonals are to each other as the sines of half the angles non-adjacent to the diagonals.

Solution by David Blackwell, University of Illinois.

$$AC=BC\,\frac{\sin ABC}{\sin BAC} \text{ and } BD=BC\,\frac{\sin BCD}{\sin BDC}.$$

Since

$$\angle BAC=\angle BDC,\ \frac{AC}{BD}=\frac{\sin ABC}{\sin BCD}=\frac{2\sin\frac{ABC}{2}\cos\frac{ABC}{2}}{2\sin\frac{BCD}{2}\cos\frac{BCD}{2}}=\frac{\sin\frac{ABC}{2}\sin\frac{ADC}{2}}{\sin\frac{BCD}{2}\sin\frac{BAD}{2}}$$

Solutions were also offered by Hyman Marcus, N. Y. C., W. E. Buker, Julius Freilich, A. R. Haynes, Tacoma, Wash., and the proposer.

1476. *Proposed by G. S. N. Ayyar, India.*

One circle is inside another. A chord of the outer circle touches the inner circle in P and cuts their radical axis in Q. Show that $AQ:BQ=\overline{AP}^2:\overline{PB}^2$.

Solution by J. Slavin, Brooklyn.

Draw QR tangent to the outer circle. Since tangents to two circles from any point on their radical axis are equal, $QR=PQ$. Therefore $\overline{QR}^2=\overline{PQ}^2$. But $\overline{QR}^2=AQ\cdot BQ$. Therefore $\overline{PQ}^2=AQ\cdot BQ$.

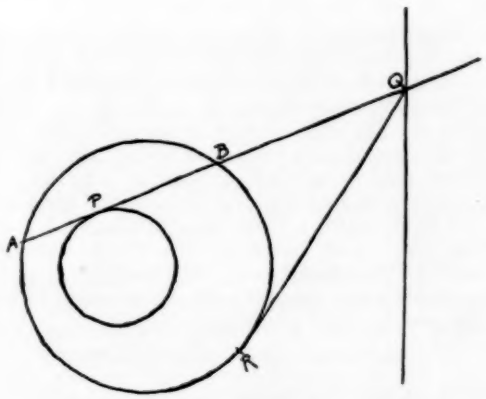


FIGURE 1476

$$\overline{PQ}^2=(AQ-AP)^2=\overline{AQ}^2-2AQ\cdot AP+\overline{AP}^2=AQ\cdot BQ.$$

Therefore

$$\overline{AP}^2=AQ\cdot BQ+2AQ\cdot AP-\overline{AQ}^2$$
$$=AQ(BQ+2AP-AQ).\text{ Since } AQ=AP+PQ, \text{ and } PQ-BQ=PB$$
$$\overline{AP}^2=AQ(AP-PB) \qquad (1)$$

$$\overline{PQ}^2=(PB+BQ)^2=\overline{PB}^2+2PB\cdot BQ+\overline{BQ}^2=AQ\cdot BQ.$$

Therefore

$$\overline{PB}^2 = AQ \cdot BQ - 2PB \cdot BQ - \overline{BQ}^2$$
$$= BQ(AQ - 2PB - BQ). \text{ Since } BQ = PQ - PB, \text{ and } AQ - PQ = AP.$$

Therefore

$$\overline{PB}^2 = BQ(AP - PB). \tag{2}$$

From (1) and (2)

$$\frac{\overline{AP}^2}{PB^2} = \frac{AQ(AP-PB)}{BQ(AP-PB)}$$
$$= \frac{AQ}{BQ}.$$

Solutions were also offered by David Blackwell, University of Illinois, A. R. Haynes, Hyman Marcus, N. Y. C., and the proposer.

1477. *Proposed by A. T. McGregor, Elk Grove, California.*

A certain number is the product of three prime factors, the sum of whose squares is 2331. There are 7560 numbers (including unity) which are less than the number and prime to it. The sum of its divisors (including unity and the number itself) is 10560. Find the number.

Solution by Charles W. Trigg, Cumnock College, Los Angeles.

First Method

Let $N = pqr$, that is, the product of three primes.

Then $p^2+q^2+r^2 = 2331$, so no one of the primes is greater than $\sqrt{2331} = 48+$.

The sum of the divisors of $N = 1+p+q+r+pq+pr+qr+pqr$. Factoring, $(1+p)(1+q)(1+r) = 10560 = 11 \cdot 960$. Hence, one of these factors is a multiple of 11. The only multiple of eleven less than 50, which is one more than a prime number, is 44, so one of the primes, say $p = 43$.

Then $(1+q)(1+r) = 240$. One of these factors might end in an even digit and the other factor would then terminate with 5. But this would require that the prime end with 4, which is impossible. The other alternative is that one of the factors be a multiple of 10, and one greater than a prime less than 50. If it be $30 = 29+1$, then the other factor is $8 = 7+1$. If it be $20 = 19+1$, then the other factor is $12 = 11+1$. $43^2+29^2+7^2 = 2739$. $43^2+19^2+11^2 = 2331$. Therefore $N = 43 \cdot 19 \cdot 11 = 8987$.

Thus a unique solution is secured without reference to Euler's ϕ function, though this may be used as confirmation, i.e.,

$$\phi(8987) = (43-1)(19-1)(11-1) = 7560.$$

It is of interest to note that there are only four sets of primes which satisfy the first relationship; 11, 19, 43; 11, 23, 41; 11, 29, 37; and 17, 19, 41.

Second Method

Let $N = pqr$. Then interpreting the given relationships,

(1) $$p^2+q^2+r^2 = 2331.$$

$$(p-1)(q-1)(r-1) = 7560. \quad \text{Expanding,}$$

(2) $$pqr-pr-qr-pq+r+p+q-1 = 7560.$$

(3) $$pqr+pr+qr+pq+r+p+q+1 = 10560.$$

Adding (2) and (3) and dividing by 2,

(4) $$pqr+p+q+r = 9060.$$

Subtracting (2) from (3) and adding the result to (1)

$$p^2+q^2+r^2+2pq+2pr+2qr+2=5331.$$
$$(p+q+r)^2=5329.$$
$$p+q+r=73.$$

Substituting in (4),

$$N=pqr=8987.$$

Solutions were also offered by Hyman Marcus, Raymond F. Schnepp, St. Mary's University of San Antonio, W. E. Buker, David Blackwell, W. R. Smith, Chicago, and Dorothy Sharpe, Knoxville, Tenn.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1463–4. *V. Krishnankutti, Sikar High School, Tiruvilwamala, India.*

1474. *Bert Fowler, Centralia, Ill., and Harold H. Sogin, Tilden Techn. High School, Chicago.*

1475. *A. G. Watson, Upper Canada College, Toronto.*

PROBLEMS FOR SOLUTION

1490. *Proposed by Arthur L. Hill, Peru, Nebr.*

One of two barber shops in a small town charges twenty-five cents for a hair cut and ten cents for a shave. The other shop charges twenty cents for a hair cut and fifteen cents for a shave. Seeing the opportunity to save five cents a man gets a twenty cent hair cut in the second shop and a ten cent shave in the first shop. How is this saving distributed between the two shops?

1491. *Proposed by Collis M. Bardin, Fresno, Calif.*

A room is 20′ by 10′ by 10′. On one of the 10′ by 10′ end walls, midway from the sides, and one foot down from the ceiling a spider walks along the surfaces of the room, floor and ceiling included, to a fly which stood on the opposite end, midway from the sides but one foot from the floor. What is the length of the shortest path by which the spider can reach the fly? What are the angles of intersection of the path with the edges of the room? Is there more than one path shorter than 30 feet?

1492. *Proposed by G. S. N. Ayyar, India.*

A pulley wheel of 12 inch radius is driven from a pulley wheel of radius 4 inch by a band 8 ft. long passed around the pulleys without crossing. Calculate the distance between the centers of the wheels.

1493. *Proposed by Mr. Ayyar.*

If N is any number other than a perfect square, and if a is the difference between n and the next larger square, and b the difference between n and the next smaller square, then $n-ab$ is a perfect square.

1494. *Proposed by Seymour J. Sherman, New York City.*

A circle center, O, is circumscribed about triangle ABC, with BP and CP tangent to the circle at B and C respectively. If A' is the mid point of BC, show that $CAA' = PAB'$.

1495. *Proposed by Robert Crookshank, Brookfield, Mo.*

If a street 40 ft. wide ends in a perpendicular cross street 35 ft. wide, what is the length of the largest girder which can be taken around the corner if the girder is always in a plane parallel to the plane of the streets.

SCIENCE QUESTIONS

March, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

NEW MEMBERS—March, 1937

167. *Howard R. Harold, University Preparatory School, and Junior College, Tonkawa, Oklahoma.*
168. *Lorraine Busse, Omro H.S., Omro, Wis., Rural Route 2.*
169. *Raymond F. Schnepp, St. Mary's University of San Antonio, Texas.*
170. *Dorothy H. Currie, Lindbergh High School, Valleyford, Washington.*

ALL DAY OUTING AND MEETING AT HUDSON, OHIO

Saturday, March 13, 1937, 10 A.M.

Science and Mathematics Teachers of Northeastern Ohio meet at Western Reserve Academy for the Annual Spring Rally on this day.

Maple Sugar, Early Flowers (Erigenia bulbosa), Sap Bilin', Good Speeches, A Good Dinner, and Good Fellowship.

(You pay for the dinner only!!!)

Bring a machine load from Your School and have a good time in the good, old-fashioned way. (Wear your rubbers!!)

WHAT SHALL BE DONE IN 1937?

777. *In the January, 1937, Number of* SCHOOL SCIENCE & MATHEMATICS *the Editor asked*—What is new for 1937?

What really is going to be done in Science Teaching in 1937 that is *new* or *different?*

Before the January issue was received, two letters that are in part answers were received and are given below.

1. *Louis T. Masson (GQRA No. 52) of Riverside High School, Buffalo writes:*

"It has been a disappointment that more of my own students as well as students from other schools have not entered into the GQRA spirit. I have been wondering if changing the invitation somewhat might not bring better results. Every teacher and many students have pet 'catch' questions in science—something that they either discovered themselves or found in some obscure place. Folks like to propose such questions to stump others. Perhaps an invitation of that kind would break the ice. The section could be given an attractive name, the gist of which would be 'Things in Science You Should Know.' The air is full of them every time the radio is turned on under the title of 'Prof. Quizz,' Molle Program, Riddle Me This, etc. From talks with my students, I know that this intrigues them and that they not only listen but go out and dig up questions to send in. If you had a small fund of several dollars a month to award to the best 2 or 3 submitted, it would help even better to start something. Such a policy may of course, be contrary to the wishes of the Editor but what I am trying to do is to help the magazine and your column in particular to be just bubbling over with the great masses of science material just aching to be publicized."

(*Since the start of the GQRA, Mr. Masson's classes have been large contributors to Science Questions.*)

Please suggest how "awards" might be made.

2. *Professor Charles W. Trigg* (*GQRA No. 20*), *of Cumnock College, Los Angeles, Calif., says:*

"The enclosure, by L. J. Adams of Beverly Hills High School, may provide some grist for your 'trade problem' mill. I do not think that any of them are original, but appear to be taken bodily from Caliban, Dudenay, Ripley, the *Mathematical Monthly*, and No. 4 from SCHOOL SCIENCE AND MATHEMATICS" (The 'Who is the Engineer' problem).

The article is too long to publish. Its title is "Don't Sprain Your Brain" in The Los Angeles ***Times***, Sunday, January 10, 1937. Professor Trigg refers especially to Nos. 1 and 14. Perhaps we can publish them later.

IS PEEBLES RIGHT?

787. *A clipping from The Niagara Falls Gazette.*

What is the correct chemistry of this situation?

WARNS TRUCK THIEVES

Stolen vehicle has load of dangerous chemicals

Washington, D. C., Dec. 25 (*AP*)—This is a warning to the person who stole a truckload of chemicals from the driver's home here yesterday.

Meade Peebles, head of the Rosslyn (Va.) Chemical Company which consigned the chemicals to a plant in Baltimore, said today they were very dangerous.

Several steel cylinders on the truck contain chlorine gas, others ammonia.

If the two get together there'll be an awful explosion, Peebles said.

FINDING THE LUSITANIA

788. (*Suggested by an article in* Esquire, *condensed in* (*January, 1937* Readers Digest).)

How does a salvage vessel (in this case the *Ophir*, Capt. Henry B. Russell) use a Location-finding Instrument?

How does the Admiralty Depth Recorder take soundings?

What principles of sound are involved?

How could they tell the water was 246 feet deep?

How could they check height and length—determining them at 84 feet high and 980 feet long.

The new diving dress "has withstood pressures equivalent to a depth of 2500 feet underseas." What is that pressure per square foot of surface?

(*Membership in the GQRA will be granted for partial as well as complete answers to 788.*)

QUESTIONS THAT CAUSED US TROUBLE

789. *Submitted by Theodore J. Kuemmerlein (GQRA No. 160), Boys Technical High School, Milwaukee, Wis.*

Here are several questions that have come up in my physics classes that caused us some trouble. Perhaps we might get some help through your "Science Questions."

1. Just what is a Seconds Pendulum?
2. What is the *correct* definition of a vibration?
3. What is the period of a pendulum?
4. One book gives $t=\pi\sqrt{\frac{e}{g}}$ another $t=2\pi\sqrt{\frac{e}{g}}$. Which is correct?

It seems that several of the newer (and old) physics books are not in agreement on these things. Just what is correct, and why can't the authors of high school physics texts agree?

WHETHER OUR SCIENCE COURSES ARE AFFECTING OUR STUDENTS IN PRACTICAL WAYS

790. *A Continuation of This Title from February, 1937, Number of* SCHOOL SCIENCE & MATHEMATICS.

Tests—Proposed by Collis M. Bardin (GQRA No. 158), Washington Union High School, Fresno, California.

I enclose a set of questions for your GQRA in SCHOOL SCIENCE AND MATHEMATICS which may be of interest. This is the present form of a set which I have been slowly developing for some time and have used at the beginning and the end of the year in an attempt to learn *"whether our science courses are affecting students in practical ways."*

The selection of questions is neither complete nor well-balanced as yet. Nor are there any "conclusions" of great interest. I have, however, found the results interesting and helpful in improving our instruction. It should be noted, of course, that the emphasis in that instruction is on understanding of principles and that the specific applications used in the test are in no way emphasized because of their occurrence there.

I recognize the limitations of your space, and if I were to select a few of the questions as having been most interesting as to results, I would suggest: 8, 15, 16, 17, 19, 37, 68, 71, 73, 75, 76, 80, 83, 85, 89. Stars are placed opposite these numbers in the lists that follow.

Four points are noticeable to date; a) the unpredictably complete ignorance of some students of what are often assumed to be items of common knowledge, b) the occasional question which is more often answered correctly by poor students than by good students—this persisting sometimes in spite of revisions of form, c) the questions in which the sophistication of a little learning proves disastrous and more wrong answers are received after instruction than before, and d) the appreciable average gain in correct answers as a result of instruction.

Questions 1–80 appeared as 781 in February, 1937.
Questions 81–121 appear as 790 in March 1937.
Questions 122 to 187 will appear in a subsequent issue.

81. Tuberculin testing is worthless if the milk is to be *pasteurized.*
82. *Pork chops* should be cooked a minimum of twenty minutes.
83*. Heating to the boiling point is an *adequate* safeguard against *botulinus* poisoning.
84. When spoiled *food* results in illness, the products of the decomposition of the food are the *cause* of the illness.
85*. *Spray* residues are adequately *removed* from fruit by scrubbing in water.
86. Vanilla should contain no *coumarin* nor artificial coloring.
87. No *hair dye* except possibly henna can be considered safe.
88. The vapor of carbon *tetrachloride* is toxic.
89*. Enough *moth balls* (naphthalene) to create a distinct odor would be sufficient to control moths.
90. Fuller's earth is often useful in removing *grease spots* from silk.
91. Seismotite is too hard for *silver* polishing.
92. The most efficient *adjustment* of Bunsen type *burners* has a flame of maximum height.
93. *Deep well* water may be contaminated from the surface.
94. Strange *drinking water* may be made safe by treatment with small correct amounts of iodine or chlorine.
95. Hypochlorites or chlorinated lime may safely be used as a source of *chlorine* for safeguarding small temporary water supplies.
96. If minor *cuts* need *covering*, only sterile cloths should be used.
97. Mercurochrome should be used for routine *treatment of minor* cuts and scratches.
98. Tincture of *iodine* loses its strength on standing.
99. No solvent is *safe* for dry-cleaning whole articles at home indoors.
100. Carbon disulphide is a *non-flammable* grease solvent.
101. *Acid in the eye* should be immediately washed out with saturated boric acid solution.
102. *Alkali on clothing* may well be neutralized with dry baking powder.
103. All food is more *wholesome* cooked than raw.
104. *High octane* rating is useful only in cars designed to utilize it.
105. It is more economical to use a separate water softener than to use *soap* or *soap powders* for that purpose.
106. Lead should not be used anywhere in pipes *carrying drinking* water.
107. *Weighting* decreases the strength of any silk fabric.
108. Price is an indication of the ability of *face creams* to beautify.
109. *Dry cells* recover their strength somewhat between short *intervals* of use.
110. In *kindling* a fire, kerosene may be replaced by gasoline.

111. *Rags* that have paint, floor wax, linseed oil, or turpentine *on* them should be handled as fire hazards, due to the possibility of spontaneous combustion.
112. *Automobile* motors should be operated in a *closed space* like a garage the briefest possible time with as much ventilation as possible.
113. *Strange* drinking water is *safe* without further question if it is known to be used by a local family, to be clear cold spring water, or to have run seven miles from any source of contamination.
114. *Radium* (or other radioactive substance) is useful for the restoration of vitality in cases of anemia, old age, or general debility.
115. If natural gas, *bottled* gases (Flamo, etc.), or gasoline vapors *escape*, they tend to travel downwards along the floor or ground.
116. If dry *cleaning* whole articles is to be done at *home*, fresh cleaning solvent is safest.
117. In *dry cleaning*, scrubbing should be avoided (except with carbon tetrachloride).
118. *Tarnishing* of *silver* may well be decreased by not leaving silverware in contact with egg, cabbage, rubber, and other sulphur containing substances, or *storage* in wrappers or boxes especially impregnated to prevent tarnishing.
119. Borax and boric acid solutions are the *only* ones *safe* for use in the eyes without a physician's advice.
120. Eye irritations should be *treated* by a physician or preferably an oculist if any hard substance or irritating solution has gotten into the eye regardless of apparent lack of damage or pain.
121. In cases where *breathing has stopped* as a result of gas, water, etc., *you* know how to give artificial respiration, you would start it immediately, you would have it continued without intervals for four hours if necessary, and if breathing resumed you would stand by in case further artificial respiration was necessary.

TRADE NUMBER 1

771. (*As numbered in December, 1937, issue—should have been numbered 772.*)

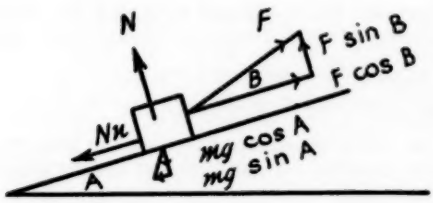
Proposed by Tully F. Watson (GQRA No. 163), Northeastern Teachers College, Tahlequah, Oklahoma.

The minimum force required to slide a mass (m) at constant velocity up an inclined plane of inclination A is of magnitude

$$\frac{mg}{\sqrt{1+n^2}}\,[n\cos A+\sin A]$$

and it makes an angle B with the inclined plane, where $\tan B=n$. n is the coefficient of kinetic friction between the mass and the plane (one of our readers thinks form should be $F=\dfrac{mg\sqrt{1+n^2}\,(n\cos A+\sin A)}{1-n^2}$.

Solution by Howard R. Harold, University Preparatory School and Junior College, Tonkawa, Oklahoma. (Elected to GQRA No. 167.)



Let N equal the normal reaction.
Let F equal the applied force.
Then since the velocity is constant, the forces along the plane must balance and we have

$$F \text{ Cos } B = mg \text{ Sin } A + Nn. \tag{1}$$

But $N = n(mg \text{ Cos } A - F \text{ Sin } B)$. Therefore,

$$F \text{ Cos } B = mg \text{ Sin } A + (mg \text{ Cos } A - F \text{ Sin } B)n. \tag{2}$$

$$F = \frac{mg \text{ (Sin } A + n \text{ Cos } A)}{\text{Cos } B + n \text{ Sin } B}. \tag{3}$$

Differentiating (3) gives

$$\frac{dF}{dB} = \frac{-mg \text{ (Sin } A + n \text{ Cos } B) \text{ } (n \text{ Cos } B - \text{Sin } B)}{(\text{Cos } B + n \text{ Sin } B)^2} \tag{4}$$

and

$$\frac{dF}{dB} = 0 \text{ if } n \text{ Cos } B - \text{Sin } B = 0, \text{ or } n = \tan B. \quad Q.E.D.$$

The standard test for maximum and minimum shows that the above value of n makes F a minimum. Substituting $n = \tan B$ in (3) gives

$$F = \frac{mg}{\sqrt{1+n^2}} (n \text{ Cos } A + \text{Sin } A). \tag{5}$$

TRADE NUMBER 2—MORE SOLUTIONS

773. *Proposed by James C. King (GQRA No. 154).*

A "guy" had a thousand dollars and ten bags. How shall he distribute the money in the ten bags so that he can give out any amount in dollars from one to a thousand without having to take any money out of any of the bags?

Solution by Raymond F. Schnepp (Elected to the GQRA No. 169), St. Mary's University of San Antonio, San Antonio, Texas.

The amounts in the ten bags are:

1, 2, 4, 8, 16, 32, 64, 128, 256, 489.

The first nine numbers are the first nine powers of 2, and hence they suffice to form any whole number up to and including $511 = 2^9 - 1$. Therefore, these numbers, added to 489, will form the remaining numbers up to and including 1000.

Also solved by Lorraine Busse (Elected to GQRA No. 168), Omro High & Webster Manual Training School, Omro, Wis.

Two Solutions by Glenn F. Hewitt (GQRA No. 151), Chicago, Ill.

The solutions to this problem are based on the fundamental theorem of the binary number system, viz., any integer can be expressed as the sum of powers of 2, none repeated.

First Solution

One bag must contain \$1 to pay odd amounts; the second must contain \$2 otherwise \$2 could not be paid; the sum of the first two bags would pay a \$3 debt; there is no way to pay \$4 with the first two bags, so the third must contain \$4; \$5 may be paid with the first and third; \$6 with the second and third; \$7 by the sum of the first three. Since \$8 cannot be paid by any combinations of the first three bags, the fourth must contain \$8. Containing a similar analysis, we get for the first nine bags respectively the geometrical progression \$1, 2, 4, 8, 16, 32, 64, 128 and 256. It will be noted that these values are the powers of 2: 2^0, 2^1, 2^2, 2^3, 2^4, $\cdots$, 2^8. By the formula for the sum of the terms of a geometrical progression, the sum of the money in these nine bags is \$511. Since the tenth bag contains the rest of the \$1000, it therefore contains \$489. By means of these ten bags, any integral sum up to and including \$1000 may be paid out.

Second Solution

The number of sums payable by any group of n bags may be found by ascertaining the number of combinations of n bags taken r at a time, where $1 \leqq r \leqq n$. This formula is

$$_rC_n = \frac{n!}{r!\,(n-r)!}$$

When $n=1$, one sum can be paid.
When $n=2$, the formula gives $c=2$, or a total of three sums payable.

When $n=3$, by the formula:
1 sum payable with 3 bags at once.
3 sums payable with 1 bag at once.
3 sums payable with 2 bags at once.
—
7 sums, total payable with 3 bags.

When $n=4$, by the formula:
1 sum with 4 bags at once.
4 sums with 3 bags at once.
6 sums with 2 bags at once.
4 sums with 1 bag at once.
—
15 sums, total payable with 4 bags.

When $n=5$, by the formula:
1 sum with 5 at once.
5 sums with 4 at once.
10 sums with 3 at once.
10 sums with 2 at once.
5 sums with 1 at once.
—
31 sums, total payable with 5 bags.

Etc.

Summarizing:

1 bag pays at most 1 sum, i.e., 1 sum only.
2 bags pay at most 3 sums, i.e., 2 sums more than 1 pays, both different.
3 bags pay at most 7 sums, i.e., 4 sums more than 2 pay, all different.
4 bags pay at most 15 sums, i.e., 8 sums more than 3 pay, all different.
5 bags pay at most 31 sums, i.e., 16 sums more than 4 pay, all different.
6 bags pay at most 63 sums, i.e., 32 sums more than 5 pay, all different.
7 bags pay at most 127 sums, i.e., 64 sums more than 6 pay, all different.
8 bags pay at most 255 sums, i.e., 128 sums more than 7 pay, all different.
9 bags pay at most 511 sums, i.e., 256 sums more than 8 pay, all different.

511 *different* sums, total of 9 bags.

Since one thousand sums are to be payable, this leaves 489 sums to be paid by using the 10th bag. But since the sums to be paid are the integers from 1 to 1000 inclusive, then the second pays two sums more than one pays, i.e., \$2 and \$3. The third bag enables us to pay 4 more than two bags permit (viz., sums of \$4, \$5, \$6 and \$7), etc. Hence the number of *new* sums payable by adding a new bag is an index to the amount that bag contains.

No. of Bag	1	2	3	4	5	6	7	8	9	10
∴ Amount in it	\$1	2	4	8	16	32	64	128	256	489

ANS.

[As a check, the number of sums payable by 9 bags by the formula should equal 511, the total found above in another manner:

When $n=9$, by the formula:
1 sum with 9 at once.
9 sums with 8 at once.
36 sums with 7 at once.
84 sums with 6 at once.
126 sums with 5 at once.
126 sums with 4 at once.
84 sums with 3 at once.
36 sums with 2 at once.
9 sums with 1 at once.

511 sums total]. ∴ OK.

Question: Is a solution by *means* of an equation possible?

Also, are the answers \$1, 2, 4, 8, 15, 31, 62, 127, 250 and 500, correct?

Solution and comment by Dorothy H. Currie (Elected to GQRA No. 170), Lindbergh High School, Valleyford, Washington, December 18, 1936.

Those problems contained in your department which pertain to algebra and geometry have been of particular interest to my mathematics classes. Since most of these students are science majors, they find a double pleasure in them.

JOIN THE GQRA

BOOKS RECEIVED

Modern Science Problems, A Textbook in General Science, by Ellsworth S. Obourn, Head of the Science Department, John Burroughs School, Clayton, Missouri, and Elwood D. Heiss, Head of the Science Department, State Teachers College, East Stroudsburg, Pennsylvania. Cloth. Pages v+322. 21×27.5 cm. 1936. Webster Publishing Company, 1808 Washington Avenue, St. Louis, Mo. Price $1.08.

Our World of Living Things, by Elwood D. Heiss, Head of the Science Department, State Teachers College, East Stroudsburg, Pennsylvania; Ellsworth S. Obourn, Head of the Science Department, John Burroughs School, Clayton, Missouri; and J. Gordon Manzer, Teacher of Science, High School, Tenafly, New Jersey. Cloth. Pages vi+274. 21×27.5 cm. 1936. Webster Publishing Company, 1808 Washington Avenue, St. Louis, Mo. Price $1.08.

Youth Studies Alcohol, by Kenneth M. Harkness, and Lyman M. Fort. Cloth. Pages x+123. 13.5×19 cm. 1936. Benj. H. Sanborn and Company, 131 Clarendon Street, Boston, Mass. Price 64 cents.

School Health Problems, by Laurence B. Chenoweth, Professor of Hygiene, University of Cincinnati, and Theodore K. Selkirk, Instructor in Pediatrics, College of Medicine, University of Cincinnati. Cloth. Pages xii+387. 14×21.5 cm. 1937. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $3.00.

A School Algebra, by R. M. Carey, Assistant Master, Rugby School. Cloth. Pages viii+288+33. 12×18.5 cm. 1936. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price $1.50.

Practical Physics for Inter. B.Sc. Students, by H. M. Browning, and L. Starbuck. Cloth. Pages x+146. 12×18.5 cm. 1936. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 3s. 6d. net.

The Evaluation of Higher Institutions, by Melvin E. Haggerty, Dean of the College of Education, University of Minnesota. Cloth. Pages xxi+218. 13.5×19 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $2.00.

How to Use the Educational Sound Film, by M. R. Brunstetter, Director, Bureau of Publications, Teachers College, Columbia University Cloth. Pages xiii+174. 15.5×22 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $2.00.

Mechanics, Molecular Physics, Heat and Sound, by Robert Andrews Millikan, Director of the Norman Bridge Laboratory of Physics, California Institute of Technology; Duane Roller, Professor of Physics, University of Oklahoma; and Earnest Charles Watson, Professor of Physics, California Institute of Technology. Cloth. Pages xiv+489. 15×23 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $4.00.

Mathematics Through Experience, Book One and Book Two, by Joel S. Georges, Chairman of Department of Mathematics, Wright Junior College, Chicago; Robert F. Anderson, Formerly Professor and Head of Department of Mathematics, State Teachers College, West Chester, Pennsylvania; and Robert L. Morton, Professor of Mathematics, College of Education, Ohio University. Cloth. Book One, vi+378+23 pages. 13.5×

19.5 cm. 1937. Price $1.00 Book Two, vi+394+27 pages. 13.5×19.5 cm. 1937. Price $1.04. Silver, Burdett and Company, 39 Division Street, Newark, N. J.

Integrated Mathematics Review, by Theodore Herberg, Head of Mathematics Department, High School, Pittsfield Mass. Paper. Pages iv+44. 14×22 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price 24 cents.

Modern School Mathematics, Book Three, by Raleigh Schorling, Head of Department of Mathematics, The University High School, and Professor of Education, University of Michigan; John R. Clark, The Lincoln School of Teachers College, Columbia University; and Rolland R. Smith, Specialist in Mathematics, Public Schools, Springfield, Massachusetts. Cloth. Pages xviii+462. 12.5×18.5 cm. 1936. World Book Company, Yonkers-on-Hudson, New York. Price $1.24.

Analytic Geometry, Alternate Edition, by W. A. Wilson, Professor of Mathematics, Yale University, and J. I. Tracey, Associate Professor of Mathematics, Yale University. Cloth. Pages xvii+296+18. 13.5×20 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.12.

A First Course in the Differential and Integral Calculus, by Walter Burton Ford, Professor of Mathematics, The University of Michigan. Revised Edition. Cloth. Pages vii+369. 15×23.5 cm. 1937. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $3.00.

On Jungle Trails, by Frank Buck, Author of ***Bring'em Back Alive***. Cloth. Pages vii+280. 12×20 cm. 1936. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price 96 cents.

Arithmetic Achievement Tests, Form I, by Gertrude H. Hildreth, Lincoln School of Teachers College. For Grades Two Through Six. Paper. 7 pages. 1936. Bureau of Publications, Teachers College, Columbia University, New York, N. Y.

BOOK REVIEWS

Astronomy for the Layman, by Frank Reh, Cloth. Pages xvii+308. 13.5×20.5 cm. 1936. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y.

The author of this book has made popular education in astronomy his hobby for many years. The experience gained with amateur astronomy clubs, by lectures to Boy Scouts, church and club groups, by radio talks, and as a teacher of both secondary school and college classes has eminently prepared Mr. Reh for this contribution to the popular science library.

The book opens with a brief chapter on the astronomy of the ancients. This is followed by chapters on the measurement of astronomical distances, stellar magnitudes, motions of stars and their colors, double stars, variables, clusters, and the Milky Way. All of the constellations are described and diagrammed. The section on the solar system gives the lay reader a vivid picture of the near celestial bodies. All of the descriptions of the constellations, stars and planets are enriched by legend, mythology, and poetry. It is a book that will interest everyone and, although it appeals strongly to the imagination, it is scientifically accurate and reliable.

G. W. W.

Down to Earth, by Carey Croneis and William C. Krumbein, Department of Geology, The University of Chicago. Cloth Pages xviii+501. 16×23 cm. 1936. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $3.75.

This book was written primarily to meet the demands of the survey course in physical science at the University of Chicago, but it is equally adapted to the needs of students in elementary geology under any type of organization. The outstanding features of the book are its attractive appearance, large type, easy, ultra-modern style, and unique illustrations. By striking chapter headings, cartoon-type illustrations, and rotogravure pictures the authors appeal to the travel, play, and entertainment interests of students and reduce study to the plane of recreational reading. The rotogravure pictures are grouped into sixteen page sections which illustrate the preceding and following chapters. Each picture is accompanied by a description which is often extensive and always highly educational.

The text starts with the contributions of geology to commerce, industry, and wealth. It interprets geology in its relation to the other physical sciences and to biology. It develops appreciation for the enormous extent of time, the great age of the earth, and the mighty forces that build the mountains and carry them to the sea. Sufficient material is included to give an understanding of all phases of geology so that the student finishes the course with a comprehensive view of the entire field, a working knowledge of its materials, and a firm resolve to read, to see, and to know more about the subject.

G. W. W.

Handbook of Chemistry and Physics, edited by Charles D. Hodgman. Associate Professor of Physics of Case School of Applied Science, Twenty-first Edition. Cloth. Pages xviii+2028. 10.5×16.5 cm. 1936. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price $6.00.

The 1936 edition of the *Hand Book* has maintained the high standard set by the twenty previous editions. The division of the content into five major sections, separated by stiff colored paper, as used in the former edition is retained in the new issue. The announcement of the publishers has been found correct in every detail and is reproduced here, in part.

"The Twenty-first Edition of the *Handbook of Chemistry and Physics* represents an increase of over 175 pages of new composition entailed by complete revision of several important tables.

"The Mathematical Section presents several new features. The numerical table of former editions has been replaced by a new and improved form. It now appears in two parts, the first of which gives the reciprocals and the circumference and the area of circles. The second part is devoted wholly to squares, cubes and roots, and all values are given to at least seven significant figures. The square roots of $10n$ and the cube roots of $10n$ are included.

"A table of haversines and considerable material on statistics have been added, and the order of arrangement altered so as to place the four- and five-place logarithm tables at the front of the volume.

"The collection of laboratory arts and recipes has been completely revised and enlarged by material sent in by a large number of contributors in charge of or associated with educational or commercial laboratories.

"The photographic section has been much enlarged and includes a large variety of new formulas and a completely revised table of plate and film speeds given in the Scheiner and in the Weston systems."

Other additions are a seventeen page table on the properties of commercial plastics, a new table of isotopes, and numerous minor changes and additions.

G. W. W.

General Entomology, by Robert A. Wardle, Professor of Zoology, University of Manitoba, Winnipeg, Canada. Cloth. Pages vii+311. 13.5 ×21.5 cm. 1936. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.25.

The preface informs us that "this book is intended for students to whom the subject of entomology represents merely one or two courses of the many that comprise their training for the profession of zoology or agriculture, and who do not require the detailed knowledge of insect morphology and insect classification that is essential to the professional entomologist, but do require a broad appreciation of the basic principles of the subject."

Nearly half the volume is devoted to separate chapters on: External Anatomy; Internal Anatomy Development and Life Cycle; Physiology; and Behavior. This part of the book is of special interest to the general biologist.

The remainder is made up of seven chapters on the various orders of insects. Here the author adopts what he considers an "eminently orthodox" system of classification, based on the Brauer-Sharp-Shipley system. Forty orders—twelve of which are known only as fossils—are recognized. A novel feature consists in naming the leading North American authorities for each of the principal groups.

The book is a fine example of clear and readable scientific composition. It is illustrated with ninety-six figures, almost all of which are simple line drawings. There is an index. The printing is excellent, and the binding is attractive and substantial; a sticker advises that the latter is water resisting and vermin proof.

EDWARD C. COLIN

College Algebra, by H. C. Carter. New York; Prentice-Hall Inc., 1936.

This text presents a very brief course in College Algebra plus an introduction to statistics. The author makes a point of giving concise explanations, so concise, in fact, that this critic believes the student will find them entirely inadequate.

Further much supposedly general theory is explained by simply working a special numerical example. In the usual text a similar example is given as an illustration of the general theory just developed. The author in several instances demands that formulas be memorized instead of the line of reasoning by which they are obtained. Descartes' Rule of Signs is not completely stated. Though Horner's method is given, no method for finding rational roots is given. In the general definition of a determinant the idea of inversion is used instead of the more logical one of interchanges. The treatment of determinants is incomplete. The author does not develop the necessary and sufficient condition that a homogeneous system of linear equations have a solution other than the trivial one, $(0,0,\ldots,0)$. A true understanding of this basic theorem helps greatly in the study of Analytic Geometry.

The book has a good selection of problems. Graphical work is emphasized throughout and there are a number of illustrative graphs. The book stresses the practical applications of Mathematics. For the instructor who has the time and desire to present and supplement the required general theory the book should serve as a satisfactory text.

JOHN J. CORLISS

Health for Body and Mind, by Walter Frank Cobb. B.P.E., C.P.H., M.D. Medical Examiner, Department of Hygiene, College of the City of New York. Cloth. Pages xvii+534. 13×20 cm. Illustrated with figures and numerous charts. Published by D. Appleton-Century Company. Inc. New York. 1936. Price $1.60.

The theme of this book is just what its title implies, with emphasis on good health. The chapters are so arranged that each chapter may be separated into two or three lessons or units which may be studied separately—even with an interval of time intervening. This is to favor schools where the subject is pursued over a considerable length of time—perhaps two or more years.

The charts are original and are all designed to reenforce as well as to illustrate the lesson being treated. Most of the charts are full-page and easily understood. They should be a great help to the teacher. At the end of each chapter are lists of review questions, "thought problems" and "suggested activities," all well chosen.

The spirit of the book is well illustrated by the following "Code of Sportsmanship" which we find at the close of a chapter on the "Physiology of Exercise," which is divided into two sections—"Classification and structure of muscles" and "Principles that underlie healthful exercise."

This is the "Code."
Keep the rules.
Keep faith with your comrade.
Keep your temper
Keep yourself fit
Keep a stout heart in defeat
Keep your pride under in victory
Keep a sound soul, a clean mind, and a healthy body
Play the Game.

It is needless to say that we highly approve this book.

W. WHITNEY

General Biology, by James Watt Mavor, Union College. Cloth. Pages xxvii +729. 15×24 cm. Published by Macmillan Company, New York. 1936. Price $4.00.

This book was written for college classes and is the result of its preliminary use in class work. It is carefully written and covers the subject very thoroughly and fully. Some subjects are discussed which are not usually found in textbooks of biology. For example twenty six pages are given to history of the Earth. There are four chapters devoted to the subject of evolution, including the evolution of man. The subject of heredity is very carefully developed and discussed in two chapters.

The make-up of the book is excellent and the figures are well chosen and adequate. We have only one criticism to offer: the author is apparently a zoologist primarily, for we find twice as much space devoted to animals as to plants, and the chapters on the general subject of biology are based largely on animal life.

W. WHITNEY

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SCIENCE STUDENTS OF OKLAHOMA

The First Annual Convention of the Association of Science Students of the Oklahoma Academy of Science met at Stillwater, December 4–5, 1936. Although the Oklahoma Academy of Science has the acknowledged faculty of "bringing rain" wherever it meets, The Association of Science Students did not let the mud keep them from arriving—75 strong—from all over the state.

The student science exhibits, placed on Friday, attracted much attention throughout the two days. Posters, electrical devices, insect and plant collections, mounted birds, mammals, fish, conservation habitat displays, charters, record books and innumerable suggestions in literature interested both students and teachers of all grades. The college students displayed their research work for the observations of the Academy visitors. Thirty cars took others to the cotton gin, one of the finest in the United States, it is said.

Saturday morning began with a breakfast for the Regional Chairmen and their guests, arranged by Mrs. Vera Pulin of the Botany Department of the A. and M. College. The opening session at nine was presided over by Dr. O. M. Smith. Motion pictures of the growth of cottonseed and movements of protoplasm in the microscopic cells was presented by Dr. J. C. Ireland of A. and M. College.

The report of the Resolutions Committee was presented by Otto Smith to the business session of the Academy. It was a request that the Academy arrange for the temporary Association to become a permanent one. The Academy passed a motion instructing Ex-president Harper to appoint a committee of five, including the Director of the High School Relations Committee, to arrange for such constitutional needs and present to the Academy for sanction at its next regular meeting. . . . Another committee, to be appointed by the incoming president was approved "to review the whole problem of public school science teaching." This shows a healthy professional attitude of the educational folk in the state. There is acknowledgment of the progressive student-centered activities which develops an active democratic spirit, and the recognition of a desire of a higher standard of teaching ability on the part of the secondary teachers of science.

The following officers will serve the Oklahoma Academy of Science for the fiscal year 1936–37.

President, B. D. Barclay, Tulsa University; Vice-Pres. Sec. A (Biology), H. D. Chase, Tulsa University; Vice-Pres. Sec. B (Geology), Mrs. John Frizzell, Oklahoma City University; Vice-Pres. Sec. C (Physical Sc.), A. C. Shead, University of Oklahoma; Vice-Pres. Sec. D (Social Sc.), F. L. Lyan, University of Oklahoma; Director of High School Relations, Edith R. Force, Wilson Junior High School, Tulsa.

The Florida State Teachers Association will hold its annual convention in Orlando on March 18, 19, and 20. The Science Section will hold its meeting in the Science Rooms of the Senior High School on March 19. The following program will be presented:

1. An exhibit of new textbooks and manuals on Science, and specimens of magazines and periodicals of interest to teachers will be on display.
2. An exhibit of teaching material; maps, charts, models, exhibits, and samples of materials.
3. An exhibit of pupils' work.
4. During the hour preceding the address, a group of pupils will be at work in the chemistry laboratory engaged in: Glass etching and silvering, Dyeing textiles; preparing, Ink, Simple dyes, Sprays, Pigments, Simple

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BIFOLIATE FUNCTIONS * This monograph develops the exponential, hyperbolic and circular functions of bifoliate numbers. The logarithm of a bifoliate number is a bifoliate number. The four components, unitary, hemitropic, imaginary, jotly, of a bifoliate logarithm correspond to the four elementary factors of the corresponding bifoliate number. The hyperbolic and circular functions correspond to compound and complex factors respectively. Price one dollar. $1

BIFOLIATE Differentiation and Integration * This monograph develops the rudiments of the differential and integral calculus of bifoliate numbers. Bifoliate numbers also originate as the solutions of certain differential equations. These are the fundamental differential equations of all kinds of vibrations. Price one dollar. $1

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drugs; Distillation of kerosene from crude oil; and various other experimental work.

5. An address: "Some modern methods of teaching Chemistry" by Charles H. Stone, B.S. of Boston, Mass., and Orlando, Fla.

INDIANA HIGH SCHOOL CHEMISTRY TEACHERS' CONFERENCE

The third annual conference of the Indiana High School Chemistry Teachers' Association will be held at Indiana University, Bloomington, Ind., April 16 and 17, 1937.

Officers of the Association for the current year are: C. O. Pauley, Valparaiso, President; Kenneth Conn, Bloomington, Vice-president; June Ossenberg, Martinsville, Secy-Treas.

Membership in the Association is open to any teacher of chemistry in Indiana. Instructors from neighboring states are welcome to visit the sessions of the conference, and participate in the discussions.

PROGRAM

Friday, April 16

A. M. Observation of class room and laboratory procedure in Chemistry Dept. of Bloomington High School—Kenneth Conn, Head of Department.

P. M. Registration of members
Inspection of Chemistry Building and other points of interest in the Univ.
Chemistry for the H. S. Student—Dr. Franzen, I. U.
The First Course in Chemistry— Dr. Briscoe, I. U.
The Gay Lussac Law and Avogadro Hypothesis—F. B. Wade, Shortridge H. S.
General Discussion

Evening. Banquet for members and guests
Welcome Address—W. L. Bryan, President, Indiana University
Demonstration, The Blow-Gun of South America—Dean Howard Enders, Purdue U.
Moving Pictures—Selected topics in Chemistry.

Saturday, April 17

A. M. Technique of Directed Study in Chemistry—Prof. T. A. Allen, Head of Chemistry Dept., Male H. S., Louisville, Ky.
Demonstration, Dry Ice—Edward Zetterberg, Muncie H. S.
What Kind of Experiment Sheet?—Ralph Scott, Oxford H. S.
The High School Chemistry Library—Leda Hughes, Shortridge H. S. Indianapolis.
Standard Tests in Chemistry—B. H. Drake, Delphi H. S.

P. M. Business Session
Can Demonstration Take the Place of Individual Lab. Instruction? H. P. Harrison, Lawrenceburg H. S.
How Should the Textbook be Used? Grant Frantz, La Porte H. S.
A Comparison of the Four adopted Texts in Chemistry for Indiana H. Schools—Allen R. Stacy, Washington H. S. Indianapolis.
Pupil Demonstration—R. D. Black and students of Wabash H. S.
Chemistry Teaching in the Rural H. S.—E. W. Mehrer, Rolling Prairie H. S.
Adjournment.

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2. *The National Council Yearbooks.* Each may be obtained for $1.75 (bound volumes), from the Bureau of Publications, Teachers College, 525 West 120th Street, New York City.

II. The Editorial Committee of the above publications is W. D. Reeve of Teachers College, Columbia University, New York, Editor-in-Chief; Dr. Vera Sanford, of the State Normal School, Oneonta, N.Y.; and H. E. Slaught of the University of Chicago.

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RESOLUTIONS FOR A CONTINUOUS PROGRAM OF SCIENCE INSTRUCTION FROM KINDERGARTEN TO COLLEGE

Submitted by the CALIFORNIA RESOLUTIONS COMMITTEE

WHEREAS, the successful functioning of a democracy depends upon the ability of its citizens to think clearly and participate freely in the solution of the ever-increasing social and economic problems;

WHEREAS, the methods of science offer one of the best ways through which a citizen may be guided to the truth in making his decisions;

WHEREAS, the task of cultivating scientific attitudes, such as, open-mindedness, suspended judgment, willingness to change opinion on the basis of new evidence, search for the whole truth regardless of personal prejudice, the habit of basing judgment on the facts, is a most difficult task absolutely necessitating an extension of training time over the lives of pupils for successful accomplishment.

Therefore, we the members of the Department of Science Instruction of the National Education Association for the State of California recommend that boards of education provide for the necessary experimental procedure for the ultimate working out of a continuous program of science instruction from kindergarten to college.

Signed by members of the California Committee on Resolutions for a continuous program of science instruction:

CHARLES L. HAMPTON, Science Head, Piedmont High School, Piedmont; Chairman-Vice-President, Department of Science Instruction of the National Education Association.

EDWARD W. LONG, Science Head, Technical High School, Oakland; State Vice-Chairman, Department of Science Instruction, N. E. A.

H. I. SCHNABEL, Chemistry Teacher, Oakland High School, Oakland; Chairman, East Bay Science Section, California Teachers Association.

IRA L. JONES, Physics Teacher, Alameda High School, Alameda; Vice-Chairman, East Bay Science Section, California Teachers Association.

W. BAYARD BUCKHAM, Chemistry Teacher, San Leandro High School, San Leandro; Chairman, Chemistry Section, East Bay Science Section of the California Teachers Association.

WINIFRED SMITH, Biology teacher, University High School, Oakland; Chairman, Biology Conference Group, East Bay Science Section of the California Teachers Association.

LESLIE C. WALKER, Science teacher, Stonehurst School, Oakland; Chairman, Elementary Science Conference Group, East Bay Science Section, California Teachers Association.

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